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MAN IN A WORLD OF INSECTS

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Numerous scientific scholars have attempted to define or name the present age of biological development in line with past evolutionary ages. The geologist has referred to it as the Cenozoic Era, "the age of man." Others have referred to it as the Psycozoic Era.

This is undoubtedly the result of the general belief that man is the dominant and superior type of animal on the surface of the earth and believes that he is capable of conquering or subduing every other form of life.

Of course we are extremely egotistic. Many of us believe that the world was created for us and that everything on the earth is intended in some way, directly or indirectly, for our use or benefit. But the truth is that man is only one of the recent products of organic evolution.

It is true that man has become the dominant type of vertebrate animal but he must constantly be aware of, and compete with, the dominant type of invertebrate, "the world of insects," which comprises four-fifths of all of the animals on the earth, some 800,000 species, and which man has never subdued. One author has referred to this era as the "age of insects," another to it as the "insect menace" and a recent film which is an excellent portrayal of this struggle is entitled "The Rival World."

When primitive man arrived on the earth as a product of evolution, he found the world already occupied and well populated with insects. This has been proven to us by the paleontologist and his undisputable evidence of fossil records.

The paleontologist tells us that insects are recorded in the late Paleozoic, which was some 200 million years ago, and at that time they were well developed, so that they must have appeared much earlier. There cannot be the faintest doubt that millions of years must have transpired in the evolution of the insect world as it existed in the upper Carboniferous period. This historic evidence leads us to believe that insects came into the world some 300 million years ago or more, became highly developed through rapid multiplication by means of quickly developing, short cycle generations, and by rapidly evolving through ages of time they have become highly adapted and perfectly fitted through mutation and selection to every natural condition on the earth, down to the present time.

The mammals in general and man in particular arrived in this insect world long after the insects had taken possession of practically every habitat on the earth. Primitive man arrived not more than a million years ago, some authorities say about one-half million. Modern man has been here not more than 50,000 years. He is not so adapted as the insect; he is a comparative newcomer. He spends his time and efforts converting the materials of the natural world into man made structures and plantings. Unlike the insect, he does not attempt to live in the natural world as he found it. This causes living conditions to be more complex and more difficult.

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The evolution of the insects was apparently not always successful for in the late Carboniferous period we find enormous cockroaches and dragonflies with a wing spread of more than two feet in some species. These apparently have long since been lost as failures in a competitive organic world but look at the successful mutants which have arisen from these ancestors. The selected, present day species of roaches are the German, American, Oriental, and others which inhabit our homes and kitchens, invade our restaurants, markets, and night-clubs and are carried everywhere in trucks, steamships, airplanes and other conveyors in all type of receptacles, whether they contain food, clothing or other types of materials.

In so far as historic records are available, man has in all ages since his arrival on the earth been tormented or destroyed by the ravages of insects upon him directly or upon his food and possessions. On the other hand, he has often turned to the insect as a source of nourishment to sustain life.

The Bible is often referred to as an excellent source of history of man through a limited period of his existence. Certain portions are probably more fact recording while others are largely philosophical. The authors who wrote the Bible point out the occurrence of many insects, ants, bees, locusts, lice, fleas, hornets, flies, and moths, for example. The terrific populations of migratory locusts (grasshoppers) are described which completely destroyed the crops and devastated the fields. This is quite similar to the devastations of the forage crops of our own plain states by migratory grasshoppers—the Rocky Mountain Locust—in the middle of the 19th century.

The ant and the bee are cited in the Bible as examples of industry and aggressiveness. They are carved on Egyptian monuments. Grasshoppers, and honey and manna as insect products, are listed as foods which were apparently largely responsible for the sustenance of the children of Israel while they were sojourning in the wilderness.

Honey was a marketable product several thousand years ago; it was used in sacrificial offerings and was attributed to have medicinal qualities by the ancient people.

The majority of insect species have no economic status and are seen only incidentally by man. They are considered as neutral. The remaining forms could be divided into two groups, the constructive and destructive. If man attempts to evaluate the role of his economic insect associates, he will need to place on the ledger both assets and liabilities, namely, those insects which assist him and those which destroy him.

We speak of many insects as being beneficial to man, and although we may be reluctant to admit it, we are actually dependent upon insects for much of our food supply, either directly or indirectly. In fact, the peoples of the world could not be fed today except for their assistance.

Insect Assets—The Constructive

Insects and pollination.—Biologists in general have agreed that one of the major benefits derived from insects is the production of crops which result from their services as pollinating agents. It would be difficult to estimate the value to man of pollinating insects, but the sum is enormous.

Research and study have demonstrated that at least 50 agricultural crops depend on flower visiting insects for pollination, or yield decidedly more abundant crops when bees are present. This list as reported by the U.S.D.A. Bureau of Entomology and Plant Quarantine includes most of the important fruits and vegetables, forage crops, legumes, and certain special crops. The real value to man is the production of seed and fruit.

Without insects to effect pollination, many species of plants will not set seed or produce fruit no matter how well they are cultivated, fertilized, and protected from diseases and pests.

Although the honey bee is the most important pollinating insect, it is but one of many species of bees necessary for the perpetuation of flowering plants. Various species of flies, beetles, and other insects also visit flowers and to some extent pollinate them. The Bombyllidae are particularly known for their pollinating habits.

The importance of the honey bee is especially noted because it and certain wild bees must obtain nectar and pollen in order to nourish both the young and adults. This is not the case with other pollinating insects.

Furthermore, agricultural development has seriously interferred with the balance in nature by demanding enormous acreages for cultivation. The nesting places of wild and native pollinating insects have thus been destroyed. As a result the burden of pollination has been increased to such an extent that wild bees are no longer adequate or dependable. Honey bees must be introduced seasonally in certain specific areas for pollination, and they have thus become the most numerous of the flower visiting insects. It is essential, nevertheless, to work to conserve our native pollinating insects since some species of native bees are more efficient, bee for bee, than honey bees and will work under more adverse conditions.

Insect products.—Certain insects are of benefit to man by their direct production of materials which serve as his food, or from which he can manufacture marketable products.

The honey bees produce some 250 million pounds of valuable and nutritious food each year in the form of honey. They also produce several million pounds of wax which is used in a great variety of industries, including both war and peace time products. Wax is used, for instance, in the sealing and coating of shells, for ignition apparatus, in the manufacture of cosmetics, in candles for religious purposes, in dental supplies, in pharmaceutical salves, on carbon paper, in confections, in printers' ink, in engravers wax and in the lubrication of dies for drawing sheet metal tubes and cylinders.

In the Orient a pure white wax is produced by scale insects of the genus *Ericerus*, and in the semiarid regions of Mexico and the south-western United States wax is produced by scale insects of the genus *Tachardiella*.

Other commercial products of lesser importance or monetary value are produced by other scale insects. Especially important are the lac insects which occur in many of the tropical and subtropical countries, such as Ceylon, Formosa, India, the East Indies, and the Philippine Islands. These insects encase their bodies with a secretion which encrusts the limbs and twigs of trees upon which they live with a resinous deposit one-fourth to one-half inch thick. This wax is melted, refined, and placed on the market as shellac and is used extensively in the manufacture of paints and varnishes.

Certain other scale insects are called cochineal insects and are common on cacti in Mexico. Their bodies are collected, dried, and used by the native Indians for the preparation of a crimson or vermilion dye. In the 19th century a cochineal manufacturing industry was established in the Canary Islands where it flourished until 1875.

Insects as food.—Indirectly, insects are of great importance to the food supply of man the world over as they supply the basic or initial food materials that are transformed into the bodies of food animals, especially birds and fishes, whose flesh later finds its way to our tables. These insects are as much a part of the food chain for fish and fowl as corn is a part of the food chain for bacon, ham, or beef we eat.

While the value and acceptability of the bodies of insects as food for man might be questioned, there are many instances where they have been or are being used. Our close neighbors, the people of Mexico utilize several types of insects as food. The larval stage of a large hesperid skipper which lives in the maguey or century

plant may be purchased alive in the markets in lots of ten or twelve, tied in a small sack made from the thin membrane of the maguey plant, or they may be purchased in cans placed in groceries or food stores by commercial canning companies.

At one of the regular meetings of the Columbus Entomological Society in 1941 these larvae were served as refreshments and some seventy-four of seventy-five persons partook of them upon this occasion.

Other insects used as human foods in Mexico are the eggs of certain aquatic Hemiptera, particularly Corixidae and Notonectidae, which are utilized for the production of an edible meal known as "ahutle." In towns near Lake Texcoco dried cakes containing these insects may be purchased in the markets.

Certain California Indians obtain in quantity from Mono Lake and other highly alkaline and saline lakes a brine fly, *Ephydra hians*, in the pupal stage, which is dried and furnishes a highly nutritious but scarcely appetizing food known as "Koochabe."

In the old world, grasshoppers have been eaten for centuries by man, native tribes commonly roasting them.

In the Belgian Congo, dried termites are sold in baskets at the native markets and termite queens are roasted or fried in fat. Termites are also eaten in the Oriental tropics.

Certain of the larvae of various large beetles are also roasted, fried, or boiled by the natives of several of the tropical countries. The Laos Indians of Siam feast upon both adults and larvae of one of the dung beetles.

Of the many specific types of insects which have been utilized as food, one of the most curious is the giant water bug, *Lethocerus*, which, being large in size, is steamed and then picked like a lobster.

Silk production.—Fiber for cloth is also furnished by the insect, providing you are financially able to purchase the cloth that is made. The silk worm has for many years been considered the second most commercially important beneficial member of the insect world. From modified salivary glands it has furnished the raw materials for large industries in both Asia and Europe, where caterpillars are reared and raw silk is produced. This has been an especially important industry of the Orient.

The chinese silkworm, *Bombyx mori*, is a native of Asia and has been reared in quantity in captivity for so many years that it is at present impossible for it to exist without human care. This rearing involves extensive hand labor. Silk is therefore a costly fiber and the industry is valued at millions of dollars. However, it is seriously threatened for its existence at present by the manufacture of synthetic fibers which are rapidly and largely replacing silk and by the growing trend toward the formation of democracies in the Orient, under which conditions the high cost of labor will be prohibitive.

Insects in medicine and surgery.—Man has recognized the medical value of insects and for some time has used their products as therapeutic agents. Cantharidin has been produced from the bodies of blister beetles and is used in the treatment of certain conditions of the urogenital system. The importance of this drug was probably not fully realized until the second World War when shipments of insects for its manufacture could not be secured from Europe. The pharmacists then became disturbed when they learned that different species of beetles contained different percentages of cantharidin and that the species in the United States yield very small percentages. As a result cantharidin has not and apparently cannot be produced on a commercial scale from native blister beetles.

Insects as healing agents.—While considering the drug industry, we might glance briefly at the use of blowfly larvae to render aseptic and hasten the healing of surgical wounds caused by osteomyelites. In a field dressing station in France a young surgeon during World War I observed severe shrapnel wounds containing

infestations of fly maggots and noted the subsequent rapid recovery of the soldiers so infested. After returning to the United States he was responsible for the experimental treating of wounds of human patients with fly larvae of *Lucilia serricata* and *Phormia regina* reared under aseptic conditions. Through this treatment a therapeutic agent, allantoin, has now been developed and fly maggots are no longer being used. At present allantoin is being used in the treatment of osteomyelitis and other deep-seated wounds in which there is decaying tissue. The fact remains that it was through the use of fly maggots and a study of their physiologic action that a modern medical treatment was developed for a condition which was previously very difficult to cure.

Insect parasites and predators.—Although taken for granted by most biologists, some of the most valuable insects are those which live upon or within other insects, particularly noxious plant feeding species, and thus destroy them. We usually classify these as parasites and predators. Both types and quite important although the parasites are much more complex in their biology and adaptations.

Predation is a common mode of sustenance of many types of animals, including man. The powerful asilid fly thrusting its swordlike beak into a large bee re-resembles the final thrust of the glistening sword of the colorful matador into the heart of a tired and floundering bull.

The development of predation in insects is hard to trace but we know that it existed in certain forms such as the dragon flies which were major types of insects in the late Carboniferous and early Permian periods.

The habit of predation is found generally throughout the insect orders. In many species and groups, however, predation may not be beneficial to man. This is especially true in the case of the large group of aquatic predatory insects.

In case the predatory habit might be beneficial, such as the aphid feeding habit of the tree crickets, the benefit is often offset by an injurious habit such as egg laying in the twigs or stems which causes untold injury to the plant or crop.

There are many groups in which predation brings enormous value to man. This is particularly true of those insects which feed upon colonies of aphids or attack caterpillars upon the ground. Most of these have insatiable appetites and are, therefore, important factors in the control of the insects upon which they prey. Certain accurate data will further amplify this statement.

A labybird beetle, *Coccinella californica*, according to Clausen requires 475 aphids at the rate of 25 a day for development and after transforming into an adult beetle eats 34 per day during its remaining life. Perhaps the greediest coccinellid species recorded is *Chilocoris similis*, which Nakayama has found consumes on an average 1563 aphids per individual during its lifetime.

In the case of the aphis lion, *Chrysopa californica*, a larva may consume 141 aphids during its larval de‌.elopment.

The Syrphid Fly larvae have equally voracious appetites. Two species reported by Curran, *Allograpta obliqua* and *Syrphus americanus*, consumed 265 and 474 aphids, respectively, during their larval development.

The ground beetles, one of the largest families of Coleoptera often attack larger insects. We should emphasize their importance by stressing the fact that here is a predacious group which covers the surface of the earth, continuously patrolling it and devouring untold numbers of insects, particularly caterpillars whose life cycle is such that they must drop to the ground as full grown larvae and penetrate its surface twice, once to pupate and again to emerge. This offers the opportunity to our carabid patrolmen to see that few pass or repass without being apprehended. Considering the large numbers of prey that are destroyed by a single individual during the course of its life, we are forced to admit that predatory insects play a primary role in checking the increase of destructive forms and are of great value to man.

Insect parasites.—Insect parasitism is extremely diverse and it may verge on

predatism, scavengerism, and commensalism in some instances. In addition to this there is a wide range of parasitic behavior among the truly parasitic species. This is probably due to the fact that parasitism has arisen in various groups of insects independently, but certain parallel developments have occurred amohg these different types.

One group of parasitic insects is known as ectoparasites and these are predominantly blood sucking species such as mosquitoes, black flies, horseflies, blood sucking lice, bedbugs, other Hemiptera, etc., which attack vertebrate animals. With few exceptions these are not beneficial to man.

The entomophagous parasites are usually forms that feed inside of the bodies of their insect hosts and either destroy them or render them sterile so that they are not able to reproduce. These parasites are known to occur in several orders. One insect order alone, the Stepsiptera, is composed entirely of parasitic species. These develop internally as parasites of bees, wasps, and certain Homoptera.

By far the greatest number of parasites are Hymenoptera and probably half or more of the known species of this group are parasitic on other insects.

Certain minute forms like *Trichogramma* will parasitize insect eggs, and an individual parasite can develop to maturity within the egg of the host. Others such as the brachonids or ichneumons may parasitize the larvae. The larval parasites are frequently quite specific and a high percentage of the host species may be destroyed.

As an example of this type of parasitic control the soil under a tree or plant may be so completely covered by the empty cocoons of brachonid parasites that the surface appears white.

An experience encountered a few summers ago is further evidence of the percentage of parasitism. An attempt was made to secure a number of normal sphinx moth larvae on catalpa. Several hundred individuals were collected from a small area of concentrated plantings and after examining some 300 specimens not a single larva was found free from parasites.

These parasites are of enormous value to man in the continuous combating of almost every important economic insect pest and many others would probably become important pests if it were not for the parasites which constantly hold them in check.

One of the most interesting and remarkable examples of the importance of insects as natural enemies is the practical and almost exclusive use of insect parasites and predators in the control program of orchard insects in the fruit area at Kentville, Nova Scotia, Canada.

In some cases where we cannot estimate the value of natural enemies we might find that without beneficial forms the other side of the ledger, the economic losses might be greatly increased.

Insects as scavengers.—The insect scavengers are those which feed upon decomposing plants or animals, or on dung. Such insects assist in converting these complex organic materials to simpler chemicals which are returned to the soil where they are available to plants to again produce new organisms.

Carrion feeding insects such as blowflies, carrion beetles, rove beetles, skin beetles and others are of value in removing or often burying carrion. Dung beetles of several families and dung flies hasten the decomposition of dung. Insects such as termites, carpenter ants, wood boring beetles and other wood feeders are important agents in hastening the conversion of fallen trees, logs and stumps to soil. The galleries of these insects serve as avenues of entrance for fungi and other organisms of decomposition which hasten the breakdown of the wood.

We have observed the organic cycle in nature since our first recollections and as a result we have usually accepted this condition without further thought. The value of such scavengers can be best emphasized by asking how long we would be able to survive in a world where dead bodies of plants and animals were not

broken down and returned to soil and where the earth's surface would as a result in time become covered to a depth of several feet with such organic waste. These insect scavengers are indeed essential to maintaining a balance in nature.

Importance of soil insects.—Many types of insects spend part or all of their lives in the soil. The soil often provides the insect its home where many life activities and processes are carried on. Many forage above the surface carrying organic materials below, where new tunnels or burrows are continuously made. The soil is thus aerated and continuously enriched by their excretions and the decomposition of their dead bodies. In this manner soil insects improve the physical properties of the soil and add to its organic content.

We should hasten to add that soil insects vary greatly in their feeding habits and some which are root feeding forms in the larval stage, such as white grubs and wireworms, are quite injurious and are of much more harm than benefit to man.

There is no question however that many soil inhabiting forms are beneficial and are of value to man.

Insects destroy noxious plants.—A survey of insect feeding habits has established the fact that a large proportion of insects feed on plants but only a small number of these are considered pests. Many of the others may be beneficial by destroying cacti, noxious weeds or undesirable deciduous plants. It often happens that when a plant is introduced into a new geographic area it thrives to such an extent that it becomes a pest. In some cases plant feeding insects have been introduced to bring this plant under control. The prickly pear cacti (*Opuntia* spp.) were at one time introduced into Australia, and by 1925 they had spread over some 25 million acres to form a dense, impenetrable growth. In 1925 a moth, *Cactoblastis cactorum* (Berg.), the larvae of which burrow in the cactus plants, was introduced into Australia from Argentina. As a result of the continuous feeding of these moth larvae the dense cactus growth is now reduced to about 1 percent of the area it occupied in 1925.

It should be noted that weed feeding insects are not always beneficial. In some cases the weeds may serve only as an early seasonal food plant for the production of large populations which will later in the season attack and injure cultivated plants or crops. This type of problem is seen in the case of the sugar beet leafhopper. On the other hand, the insect may change its food preference from a wild to a cultivated host. The Colorado potato beetle, for example, originally fed on wild species of *Solanum* and later changed to potato.

The aesthetic value of insects.—The beauty of insects, their brillant colors and color patterns have been utilized by artists, jewelers, and designers. Some of the butterflies, moths, and beetles have provided basic patterns in many types of art. They have probably been utilized more because of their larger size and thus these patterns are more often seen. Some of the smaller insects are just as brilliantly colored and are often observed. For instance a brilliantly colored tropical leafhopper, *Agrosoma pulchella* (Guerin), has a black, white and red pattern of bars or stripes which is frequently used in Mexican and Central American art. The ecology and abundance of this insect account for its use in color designs there. It occurs in the lower tropical areas on shrubbery and is commonly found along streams where the natives launder their clothing. When their white garments are spread upon the shrubbery to dry, these brilliantly colored leafhoppers hop upon the clothing and the conspicuous color is emphasized by the white background.

Insects are also used in making jewelry, either by the use of all or part of actual specimens, or by their use in designs. Necklaces, necktie pins, bracelets, and scatter pins are often made in the design of an insect. In some tropical countries the natives make necklaces of "ground pearls," the wax cysts of female scale insects of the genus *Margarodes*. The wings of morpho butterflies, brilliant bluish butterflies occurring in South America, are often mounted under glass and

made into trays. pictures and certain types of jewelry. Showy insects mounted in plastic or under glass are sometimes made into paperweights, book-ends, and similar types of useful articles.

During the last few years the Department of Fine Arts at The Ohio State University has annually requested certain of these insects with brilliant coloring or exquisite patterns for use in its laboratories, so that students specializing in fine arts might become acquainted with this source of material and might have an opportunity to use some of these designs in their period of training.

The recreational value of insects.—Insects are fascinating animals when one takes the time to observe them or begins to study them carefully. Therefore, many persons find in the study of insects a stimulating hobby and a means of recreation, just as intriguing and beneficial as any other type of nature study.

The interest in insect study leads to collecting and field study and to observations of habits and interrelations of insects with insects, insects with plants and with other biologic forms. The collecting, hiking, field activity and mountain climbing serve as an excellent form of recreation.

In order to improve his skill and to obtain recreation a man will push a golf ball over miles of fairway as often as he has the opportunity. When he returns from his hours of recreation, he has a score card, some sore muscles, and often a headache. If the same time were taken for insect collecting, equally important skills and techniques are developed; similar physical exercise is obtained, and in place of the score card an interesting catch of specimens is available for further study and recreation. It is true that the collector often has a headache too, but usually because of the interesting or intriguing specimens that escaped from his collecting net.

The scientific and educational values of such collections are also very important phases of the use of insects as a hobby. Some of the finest collections of certain groups of insects that we have in the world today have been formed in this way and often handed down for several generations. Several of these have been developed in the United States. In spite of this fact, the United States has fallen far behind the European and Asiatic countries in the practice of collecting insects as a hobby. This practice is found especially in Japan and certain of the central European countries. Scientists from these countries who have visited the United States during the past few years have expressed their astonishment at the lack of interest by the American people and the comparatively few amateur entomologists found in our country.

Insect Liabilities—The Destructive

The liability side of the ledger is illustrated by the destructive insects which destroy our crops, eat through the wood of our homes and buildings, make sneak attacks upon our supplies of food in pantries and larders, and pierce the skin of our bodies, thereby injecting deadly disease organisms into our blood.

Insects eat, steal, or destroy one-third of everything which man grows and stores for the future. This includes fields of corn and wheat, orchards of fruits, fields of potatoes, peas and tomatoes, vineyards, citrus groves, and all other types of crops.

Certain wood boring insects attack and fell our forest trees. Others inject disease producing organisms into certain trees causing Dutch Elm disease, Phloem Necrosis or Oak Wilt which take their toll of our forest and shade trees. When not destroyed in this manner, the lumber which is made into buildings is continuously attacked and destroyed by termites and powder post beetles.

Borne diseases of man.—The most direct and fatal attacks are by those insects which feed upon the blood of man. The world health authorities, working through the United Nations and gaining knowledge and statistics from all the nations of the world, are authority for the statement that insects are the cause of one-half of all human deaths, sickness, disease, and deformity.

The anopholine mosquitoes alone are responsible for injecting into man's blood stream the protozoans which cause malaria—a scourge which infests one-sixth of the human race and kills somewhere in the world a man or woman every ten seconds. In like manner the aedes mosquitoes are vectors of organisms causing yellow fever, a much more deadly human disease although not as widely distributed throughout the world.

The *Simulium* or black flies which occur in certain tropical areas around the world, inject into man's blood the microfilaria roundworms causing blindness (onchocerciasis) in man. Large segments of the native populations are often totally blind.

The tsetse fly is one of the most deadly of the blood sucking flies, causing sleeping sickness in man, which is usually fatal. Several million square miles of Africa have been so completely dominated by this insect that man has not been able to inhabit this area. The wild game animals serve as reservoirs for the trypanosomes which are carried to man by these flies.

Reasons for an Insect World

What is the character of these rivals which humanity must surely hold in check if it is going to be successful as a species? There are probably certain reasons which could be cited to explain why the insect type has become so highly evolved, adapted, selected, and so dominant and successful on the surface of the earth. To name a few of these briefly we could mention:

1. The body is enclosed within an exoskeleton which is composed of chitin. Its essential chemical elements, carbon, hydrogen, and nitrogen are easily and abundantly available from green plants in the form of nitrogenous sugars. A body covering of this type limits the insects to small size but affords great strength due to direct muscle attachments. It also favors diversified mutation and all types and extremes of protection through form, color, and thickness of the armor. This skeleton is always properly developed, in as far as diet is concerned, in spite of the fact that usually no parent is present to select the diet and feed the young. In contrast the human infant must be carefully nourished during his early life in order to obtain a proper skeletal structure and a healthy body.

2. Insects are the only winged invertebrates and this fact, combined with other survival characteristics, has given the insects dominance of the earth with which even other winged forms like the birds cannot compete. With wings insects can quickly abandon habitats when they become unsuitable. Aquatic insects have winged stages in their life cycles which solve the problem of desiccation, or in many instances they can develop wings in time to avoid death which might be imminent in many habitats. Fish and other aquatic forms usually perish under similar adverse circumstances.

3. The temperature of an insect's body usually follows closely the external temperature to which it is exposed. In order to adjust for seasonal changes the composition of the protoplasm is such that it can function as a hydrophyllic colloid, to the extent that it can absorb and bind the free water of the body. Thus by a short period of conditioning, insects in every life stage, depending upon the species, can be subjected to freezing and subfreezing temperatures and a certain percentage can survive long periods of low temperature. This adaptation to a condition of hibernation is one of the most important survival factors in the world of insects. This is the means by which most insects are fitted into a natural world and thus solve the problems of changing seasons. During the winter their bodies are quiescent and the metabolic rate is extremely low. When food is not available, they need no feed in order to survive.

Man on the other hand, who maintains a constant body temperature, must have fuel in order to retain a normal temperature during periods of low climatic temperature, as well as warm clothing to protect his body and a good supply of food

to maintain a normal high metabolic rate and a continuous supply of internal heat and energy.

4. Metamorphosis in insects is a condition which is allied in a way to the previous consideration. Different biologic stages of activity and inactivity are often selective adaptations to seasonal conditions or feeding habits. The common cattle pest, the horn fly, is a good example of this. The only place that the larvae are able to complete their growth is in fresh cattle droppings. In hot, dry, summer weather these droppings soon desiccate. If and when they do, the maggots die. The selection factor here has produced a short maggot or growing stage of from two to four days.

Or take the case of a specialized plant feeding larva which attains great size during its short larval period. As a young apprentice of entomological research working with the United States Department of Agriculture in the tobacco growing sections of Tennessee in 1915, I was assigned the task of finding how much leaf tissue a tobacco horn-worm larva would consume between the time it hatched from the egg and the time it became a quiescent pupa. From the data I obtained and from the studies of subsequent workers, we can conservatively say that a single larva (tobacco worm) consumes in 28 days of larval growth food weighing approximately 50,000 times its birth weight, and the larva increases in size during this period approximately 12,000 times its birth weight.

Or look at the case of a silk worm larva which consumes its weight in food each day.

5. To these characteristics should be added the factor in insects of great biotic potential—the power of the insect to reproduce rapidly and establish enormous populations. This potential factor has been stressed by the theoretical estimates of many of our honest and reputable entomologists who estimate, for instance, that under optimum conditions a single cabbage aphis together with its accumulating descendents could, if enough cabbage were available, produce in a single growing season enough aphids, weighing one milligram each, to form a mass weighing 822 million tons or 5 times the weight of the total human population of the world. While this does not occur, the potential danger is always present in man's world of insects; and here or there, from time to time, where environmental resistance is restrained, the chinch bug, the Japanese beetle, the Mediterranean fruit fly, or some other specific form, will produce populations which get out of hand in spite of man's knowledge and continued efforts to subdue them.

Consider the potential of a common rainbarrel which has been observed to produce in excess of 100,000 mosquitoes in a single season. Regarding this potential, we should bear in mind that an average of only 1 per cent of the previous season's populations survives the period of wintering.

Certain insects, such as the digger wasps, in the absence of food preservation by low temperatures, habitually paralyze their prey by stinging them and then depositing their eggs upon these victims which are used to provision their galleries or burrows. In case these paralyzed insects should die the venom acts as a preservative and they will not decompose for periods of several weeks or even months.

The insect heart is a very unimportant structure in connection with respiration or oxidation. So heart disease, the great killer of humans, could not even occur in an insect. In like manner, insects have no lungs, no liver, and no kidneys. The respiratory system composed of a complex network of tracheal tubes is adapted to all types of aquatic life and is tolerant of both air and vacuum pressure, high altitude flight, and is more tolerant to radiation than vertebrate animals.

Also, consider the fact that in insects the infants, when born, usually take care of themselves; there is seldom parental care. Add to this the fact that there is no old age in insects. When their work is finished, they die. There is no retirement, no social security, no old age pensions, and never a feeble grandparent. All of these problems have solutions in a world of insects as a part of their adaptation.

Adaptations

Not only did man find these populations of insects in the world, but he also found extreme adaptations of these species by millions of years of survival selection. The extent to which insects will become adapted is amazing, and often shocking, at least when you use your imagination as to what might happen in the future. These adaptations occur in morphology, all phases of the biological cycle, habits, and physiology. May I point out a few examples of these adaptations?

The legs of insects are adapted in various groups for running, swimming, digging, grasping, and holding prey or in the case of blood sucking lice, of grasping and holding onto the hairs of mammals.

In the case of surface swimming gyrinid beetles, their eyes are divided so that one portion of the eye is above the surface of the water and the other is below.

In many insects which have hypermetamorphosis, the larva when first hatching from the egg may have well-developed legs and be able to seek out an egg mass upon which to feed; but when moulting to a second instar the legs become quite small and inadequate for locomotion. This condition is also seen in the scale insects which have an active first instar crawler stage and then become sessile and lose their legs in the second and succeeding instars.

Many interesting adaptations are seen in egg production. In some insect parasites we have a condition which is known as polyembryony. The female lays a single egg which eventually produces many individuals. Or take for instance the cannibalistic aphis lion where the survival factor is apparently accomplished by the eggs being layed on stalks and thus brothers and sisters are protected from the first of the brood to hatch.

In similar manner the giant water bug, females of the genus *Abedus*, glue the eggs to the back of the male where they remain until hatching.

Certain insects are adapted to extremes of climate. The Grylloblattids prefer temperatures of zero centigrade and apparently are unable to live at temperatures which are more than a few degrees from this point. They normally occur at the edge of melting glaciers. On the other extreme, certain insects live in hot springs with temperatures of 120° to 124° F.

There are many diversified adaptations in feeding habits and physiology among insects. The clothes moth larvae feed upon animal fiber (carotin) only, and never have available water as such. The water needed by the body is obtained through metabolic processes and the water released in the body from this source is conserved by the process of excretion and the production of dry fecal pellets. Stored gain insects conserve water in a similar way.

Gall insects, belonging to several orders, demonstrate another interesting phase of nutrition and interrelationship. In this case the insect produces a stimulus which is so specific that each individual of a gallmaking species will cause the plant to produce the same type of abnormal growth, inside of which the immature insect feeds, grows, and developes to maturity. Conversely, every different species of gall maker on the same plant will stimulate the plant to produce its own specific and uniform type of abnormal growth.

One of the most amazing adaptations is found in the ephydrid flies which live in saline, alkaline, or other solutions of extreme degree or variation. Certain of these occur in ocean water, in the Great Salt Lake, in the Bohemian salt mines, in pools of crude oil in California, and upon occasion some have been found living in cadavers in The Ohio State University Medical School which were preserved in strong solutions of formaldehyde.

An interesting survival factor is also displayed in the sexton beetles belonging to the Silphidae. These live in the bodies of exposed dead animals. The eggs are laid and the larvae develop in these carcasses, but the larvae must have soft, moist tissues to complete their growth. In hot dry weather these carcasses will desiccate rapidly. The species is thus preserved by the adults which dig the soil from under the carcass and gradually but rapidly bury it.

To the best of our knowledge the caddice fly larvae were the first organisms to demonstrate the use of nets to capture aquatic microorganisms. The dragonfly naiads, by the intake and repulsion of water to bathe the gills in the rectal cavity, gave us the first example of jet propulsion; and the paper wasps of the hornet group were the first to make paper by means of using wood pulp.

Natural Balance

It is impossible to predict what role the insects might have played in the world without the advent of man. There is no question that they had existed for millions of years and had become well adapted. Our observations, however, of areas of the world uninhabited by man have proved that natural conditions are usually well balanced until man's arrival. The number of insects and their interrelationships, parasites, predators, etc., the diversity of plants, and many other factors keep populations well balanced.

When man arrives he cuts down forests, cultivates fields containing many kinds of wild plants, and changes the fields to extensive acres of one kind of plant or crop. This breaks the balance and produces extensive populations of what we term economic insects.

The chinch bug is a good example. The corn belt was originally a grass land with an Andropogon Climax vegetation. This was the native food plant of the chinch bug which sucked the juices of the grass and hibernated in the adult stage in the clumps of dead grass at the base. Man decided he could raise the finest corn and wheat here. He plows out the Andropogon and plants two crops which he fertilizes and cultivates, causing them to grow rapidly, to be succulent and highly attractive to insects, and these two crops fit perfectly into the two seasonal generations of the chinch bug, spring on wheat, summer on corn; and then he wonders why these enormous populations destroy his crops.

In like manner man changes the course of streams, impounds water, constructs artificial barriers, and in general changes natural conditions, and in doing so he destroys the original balance.

The Struggle for Dominance

When we view man as a competitor in the insect world, attempting to subdue his invertebrate rivals, we must face up to certain facts and considerations.

The insect is an animal without intelligence, or at least the ability to think, which has come to its present position of dominance in the world by mutation, selection, and adaptation. As pointed out, it is highly adapted to most conditions in the world.

If there is any doubt concerning its ability to overcome anything adverse which is devised for its destruction, we have only to look upon the chemical developments and history of the past two decades. Man has devised the most deadly chemicals he could find in the chlorinated hydrocarbons and organic phosphates which at first seemed to deplete completely populations of houseflies, roaches, body lice, and most agricultural insects for months at a time. In five to ten years time these chemicals have proven absolutely ineffective on the descendants of these same insects.

When D.D.T. was first used, a prominent biologist stated that the house fly problem was forever solved. In five years from that date, we were rearing them in our laboratories in screen cages which were white with coatings of D.D.T. painted on the wire screen. Where does man hope to go in his fight with selective adaptation or tolerance of this type?

Man, on the other hand, is an intelligent animal with the ability to think and his choice of adaptation has been in this direction. In man we visualize another type of biologic experiment in the world. We see the development of an entirely different type of animal body with a different type of appendage, the hands,

which he uses to make tools with which to made gadgets and devices for obtaining the materials and directing the forces of the earth, thus converting or changing the natural world around him. At the moment his greatest efforts seem to be in the direction of producing mechanisms of all kinds, including missiles, bombs, and devices for the exploration of outer space.

His intelligence drives him to an expanding horizon of activity so that he vigorously competes with other men and other races in order to control greater resources and materials in the world and command greater areas of influence. This leads to cold and other wars, and the destruction of man and his valuable possessions and international relationships.

Could it be possible that man has not been here long enough to be properly established since only about a half million years have elapsed from *Pithecanthropus* to present day man, and modern man has been here a comparatively short time?

At the present moment in world affairs a sudden misunderstanding or misstep, especially with the world's present stockpile of bombs, might eliminate man from large areas of the world in a single stroke. The insect populations under similar conditions would have a much greater chance of survival.

If this does not happen, where will man be in the next million years, attempting to live in a world full of established insects? The laws of evolution should work to improve the human race, but will this happen or can it happen in the world as we know it?

In order to meditate upon this thought it is necessary to recall that man is dual in nature. He must conform to his animal nature in order to meet and supply his physical requirements, but he wishes at the same time to be a spiritual creature in order to survive the physical world. He thus becomes involved in religious theories and doctrines, and he becomes confused and perplexed by biological laws, theories, and concepts. How far will religious prejudice, archaic concepts, and ecclesiastical dictatorship deter man from a sane pattern or philosophy of biological existence? Can intelligence direct the religious to augment the biological? If so, when may we expect it?

The biologist in his rational moments studies the laws of genetics as they apply to insects. He experiments with these in order to obtain and study certain gene combinations and marvels at what has happened in their evolution and adaptation. He applies the principles he discovers for the improvement of farm crops and farm and domestic animals, but he has not applied these basic biologic laws when he considers the human species and the possible and certain improvement of the peoples of the world. In the present world, he dares not.

Man then has not and cannot compete with the insect upon the same basis. It is a case of man's intelligence against biological adaptation, and repeatedly intelligence has lost skirmish after skirmish.

We could reflect in geological terms to the fact that nothing in the whole range of biological and palenotological study shows anything to equal the insect in its persistence and its potential compliment of characteristics, which would seem to assure its continued progress even if the experiment in the world of the human species would prove eventually to be unsuccessful.

We are reasonably certain from the past and present that the insect will persist and probably increase its position of dominance in the world. Can we predict the same for man? Will it be possible for man to become human with man in time to solve the problems which face him? Will his intelligence lead to adaptive survival or destruction?

Can intelligence solve such problems as the rapidly increasing populations of the world with its many and diversified facets, the depletion of farm lands, the decreasing supplies of natural resources, the destruction of the wild populations of pollinating insects and the natural enemies of insects, the failure and diminution of more and more of our promising insecticides, the increasing ravages of crops, and the increasing spread by modern travel of insect borne diseases of man?

Can intelligence cope with and solve the international political situation, especially when this is linked with increasing stockpiles of bigger and more deadly bombs and missiles for human destruction?

If it cannot, the insect may eventually win and eliminate man from its world,' and what Dr. W. J. Holland said, might come to pass, ". . . the last living thing on the globe will be some active insect sitting on a dead lichen which will represent the last of the life of the plants."

Finding Fossil Man. *Robin Place.* Philosophical Library, New York, 1957. 63 photographs, 41 sketches, 126 pp. $7.50.

This attractive little book is written for the advanced high school student (with some knowledge of biology) interested in learning of the ascent of man and of his fossil ancestors. The thesis of evolution is carefully developed from the beginning clues through the contributions of amphibians, ancient reptiles and mammals, to early primates and fossil man. The reconstruction of "near-men," and the first men is well done; the revelation of the extinction of the Neandertal Man line and subsequent but parallel flowering of *Homo sapiens* is quite up-to-date.

Unfortunately, the out-dated Early, Middle, and Late subdivisions of the Pleistocene Epoch are retained, there being not a word even about the now generally accepted four subdivisions of the Wurm (Late Pleistocene) in Europe. The title is misleading, for less than 5 percent of the 107 text pages are devoted to the "finding" of fossil men.

The last chapter, quite out of line with the previous scientific account, valiantly argues that the legends and myths of the Bible quite naturally were all that shepherds and lonely village folk could pass on in explanation to their children of their own origin, whereas today we inherit the great wealth of information derived from the labors of our scientists, but especially from those who dig up the answers, the archeologists.

SIDNEY E. WHITE

Our Nuclear Adventure: Its Possibilities and Perils. *D. G. Arnott.* Philosophical Library, Inc. New York, New York. 1958. xi+170 pp. $6.00.

Since the development of the nuclear reactor and the subsequent production of radioisotopes, vast amounts of research have been performed and volumes of scientific and technical information published. We seldom find anything in the way of a stimulating informative essay which deals with the benefits and detriments of nuclear energy to man. One of the very fine exceptions to this is the book entitled "Our Nuclear Adventure" by D. G. Arnott.

The author considers in detail the philosophical, social, and biological implications of nuclear phenomena. He first introduces the reader to the basic facts of radioactivity, nuclear fission, and fusion. The effects of radiation upon living things is taken up in detail. The various kinds of nuclear weapons are described and the relative effects of their use in a global war is discussed. All of these topics are presented in an informative and stimulating manner. The pros and cons of the respective situations are presented and the reader is left to draw his own conclusions and inferences concerning the "possibilities and perils" of nuclear phenomena. Some of the conclusions are crystal clear while others require thoughtful, soul-searching consideration. The author points out to the scientist and to society that each has an obligation to the other. The scientist is particularly reminded of his social responsibility and that no circumstance warrants his isolation from or lessens his obligation to meet this responsibility.

The inquisitive and thinking layman and scientist will surely want to read this fine work.

WILLARD C. MYSER

PROBLEMS RESULTING FROM POPULATION GROWTH

A symposium presented at The Ohio Academy of Science at Capital University

April 18, 1959

1. Problems Resulting from Population Growth

   JORGEN M. BIRKELAND, *Chairman, Department of Bacteriology, The Ohio State University, Moderator*

2. The Expected Growth of Population in the United States

   ARTHUR A. CAMPBELL, *Scripps Foundation for Research in Population Problems, Miami University*

3. The Loss of Land to Urban Growth and Industrial Development (a slide talk summarized in Birkeland's paper)

   HAYDEN W. OLDS, *Chief, Division of Wildlife, Ohio Department of Natural Resources*

4. Will We Have Enough Food and Fiber?

   CHARLES J. WILLARD, *Department of Agronomy, The Ohio State University*

5. Can Technology Solve the Materials-Needs Problems of the World?

   ALFRED B. GARRETT, *Chairman, Department of Chemistry, The Ohio State University*

6. What Effects Has Population Growth on People?

   DAVID F. MILLER, *Chairman, Department of Zoology and Entomology, The Ohio State University*

These several papers, with the exception of J. M. Birkeland's, were presented before the Conservation Section of The Ohio Academy of Science at the 1959 annual meeting of the Academy. Dr. Birkeland was moderator of the discussion and subsequently prepared the introductory paper published herein which also summarizes the ideas and conflicts which emerged from the discussions. Carl S. Johnson of The Ohio State University, program chairman for the Conservation Section, served as the symposium editor.

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PROBLEMS RESULTING FROM POPULATION GROWTH

JORGEN M. BIRKELAND
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In the year or so since the papers in this series were presented at the annual meeting of The Ohio Academy of Science, the world population has increased by over 40 million; death rates from all the important infectious diseases have declined; food surpluses have continued to pile up in the United States; and in the rest of the world millions on millions have gone from day to day with barely enough calories to keep alive and reproduce, but not enough to walk upright in decency and with human dignity.

Ever since Malthus, in 1798, published his famous essay on population in which he "proved" that man's capacity to reproduce exceeded the earth's capacity to produce food, there have been countless writers who have "disproved" the Malthusian doctrine. But in spite of the discovery of new food producing areas, in spite of man's increasing mastery over nature through science and technology, by which he has been able to produce more food, in spite of the industrial revolution, all of which had the effect of postponing the evil day of reckoning, until many felt that the dire prophesy of Malthus had been thoroughly disproved, the problem, the nasty problem of over population, somehow still haunts us.

It haunts us chiefly because the rate of population increase has increased so rapidly in the immediate past that if the present rate continues for another forty years, the world population will more than double in the period from 1960 to 2000. It took over a million years to reach a population of 2.8 billion; it will take only forty years to reach a population of 6 or more billion. By 2050 the population might be 9 to 10 billion, and nobody cares or dares to predict much farther ahead.

There are those who see nothing but good in numbers, "The more the merrier"; there are others who see little merriment in half-starved billions of humans.

There are those who say that they need not starve, that the world can feed even 10 times our present population, and that therefore there is no population problem as such.

There are those who point to the limitation of other natural resources, such as energy and minerals. These and other questions are considered in the papers that follow.

In the past, most predictions as to the rate of population increase have been rather consistently inaccurate. Dr. Campbell's paper deals effectively with the problems of forecasting population growths and, on the basis of his analysis and his most conservative projections, we must look forward to such a rapid increase in the United States in the next twenty years that the fundamental aspects of our daily lives will be profoundly changed.

When we think of Malthus, we think of food and starvation. Professor Willard emphasizes several points which are either overlooked or forgotten in many of the discussions of the food and population problem. Although he does not see any immediate threat of starvation in the United States and feels that the world, by mobilizing all its resources, can certainly support many more people that we now have, he still feels that eventually the population growth will outstrip the earth's capacity to feed the people and that, consequently, population control is inevitable. What he does realize, but does not emphasize, is the fact that to mobilize all the resources, to desalt sea water, to farm the deserts and oceans, will require a fantastic amount of investment capital far beyond the resources of the over-populated countries.

Any statement of the food producing capacity of a nation must take into

account the competition for land for other purposes. Hayden Olds (whose paper is not included)[1] presented figures showing the acreage taken out of agricultural production and used for airports, golf courses, cemeteries, farm ponds, new industrial plants, roads, and recreation. From his, and other data, the situation may be summarized as follows. About 4 percent, or 17 million acres, of the best farmland in the nation has been taken out of food production and used for other purposes during the period 1940–1954. The rate of loss of agricultural land is rapidly increasing and land covered with concrete or urban development isn't likely to come back into agricultural production. The need for land for our expanding industry may be illustrated by the fact that in Ohio since 1953 new industrial plants have been established at the rate of slightly more than one each week, or 57 per year. Every highway, every mile of highway with a right-of-way of 200 feet, takes 26 acres, not counting cloverleaves or intersections and peripheral developments.

Another point might be emphasized. The need for recreational facilities will increase even more rapidly than the rate of population growth because the more crowded we become, and the more our daily life resembles the "poultry broiler factories," the greater the need for parks, playgrounds, and other recreational facilities.

One wonders whether those who have calculated our capacity to produce enough food for ten or twenty billion or a hundred billion ever consider the other demands for space.

Professor Garrett, in dealing with the question "Can technology supply our material needs?" cites theoretical levels which are so high that no one believes they can be reached. Calculations based on theoretical capacity to produce do not take into consideration economic, political, or social problems and, moreover, do not take into account what might be called "test years." Certainly a drought, or floods, can upset all calculations for short periods and man must eat three times a day, every day, and he can't eat averages. The ecologist knows that it is the extremes, not the means, that limit organisms and this applies to human ecology as well.

Professor Miller, in discussing the effect of population growth on people, raises many important ecological questions and wonders whether *Homo sapiens* can survive unless he uses his intelligence to deal with the population problem. This would appear to mean unless he decides to limit the numbers and to limit the rate of increase now and by methods which will work. It is by the use of intelligence that man introduced death control and unless he introduces birth control, the problem of survival will eventually defeat him.

One could ask how large a world population can be supported when there are about a hundred separate and independent governments. How close to the theoretical maximum capacity to produce food and energy and material can we come unless we have one world government with a dictator powerful enough to shift people so as to get the most efficient use of land, water, mineral resources and capital, without regard for human rights, wants or traditions?

We might also ask how we can expect people, who because of ignorance, traditions, and lack of capital have not been able to deal intelligently and effectively with their present population problem, to display suddenly the scientific knowledge and technical skills necessary to wring the maximum productivity from our present crop lands, to provide the water for irrigating the deserts, to farm the oceans, and to organize the economy so it will operate at maximum efficiency when confronted with their problem magnified four to tenfold.

A great many articles, many television and radio programs have dealt with the population problems since these papers were presented but, because of their

[1]Haydon Olds, Chief of the Division of Wildlife, Ohio Dept. of National Resources, presented aerial views by color slides giving evidence of the pressure of urban developments upon space for agriculture and recreation.

fundamental nature, these are in a sense timeless and will repay careful reading.

One last comment may be permitted. In one sense the most important statement to appear during the last year is the one issued by the Roman Catholic hierarchy and called "Explosion and Backfire."

This statement, although hardly convincing to the Malthusians, has brought the issue of population control into the open. While the problem has been discussed freely and frankly in many other countries and by some in this country, the very mention of "birth control" in any audience has usually caused an uneasy stirring and a tendency to change the subject. Convictions or actions based on religious dogma are considered in a sense "untouchable" and not proper topics for discussion. While the statement does not admit of a population explosion, it certainly caused an explosion in the press, on radio and television. Whether it will backfire only time will tell. At any rate, it did clear the air and it is now much easier to discuss freely this highly emotionally-charged problem.

THE EXPECTED GROWTH OF POPULATION IN THE UNITED STATES

ARTHUR A. CAMPBELL

Scripps Foundation for Research in Population Problems, Miami University, Oxford, Ohio

At the outset, it must be emphasized that nobody can predict population growth with a high degree of accuracy. Population experts have had many opportunities in the past to demonstrate their inability to foresee the future clearly, and they will undoubtedly have many more opportunities to do so in the future. The trouble is, of course, that people do not always behave as we expect them to.

Some of the strengths and weaknesses of earlier attempts to forecast population growth can be illustrated by projections prepared by Pascal K. Whelpton in 1927 (Whelpton, 1928). These were the first projections for the United States made by the so-called component method. With this method each of the three components of growth—fertility, mortality, and migration—is projected separately. Projections are prepared for each age-sex group, and the results are added to obtain a figure for the total population. Whelpton's 1927 forecasts were only 0.5 percent above the correct 1930 population, but by 1940 they were 4.6 percent too high. They nearly hit the mark in 1950, 23 years after they were prepared, with a deviation of only 0.5 percent from the true figure, but by 1955 they were 4.3 percent too low. What had happened was this: the forecasts were too high by 1940 because Whelpton had failed to foresee the low birth rates of the depression decade of the 1930's. However, the 1950 forecast was just about right because the low birth rates of the 1930's were balanced by high birth rates after the war. The 1955 forecast was too low because actual fertility between 1950 and 1955 was higher than expected back in 1927. You will note that I assign the major responsibility for the successes and failures of these projections to fertility, which is the major unknown in population forecasting for the United States as a whole. Although there were defects in Whelpton's forecasts of mortality and migration, they did not affect greatly the accuracy of his forecasts of total population.

One way of overcoming the deficiencies of such early attempts to forecast population growth is to project not a single series of figures, but a range within which the true figure seems likely to fall. A major attempt to do this was undertaken by Whelpton, Eldridge, and Siegel for the Census Bureau in 1945 and 1946 (Whelpton, 1947). Seven series of projections were prepared by a very

careful application of the component method. Forecasts of the total population for 1970 ranged from a low of 152 million to a high of 177 million. In all probability, we will reach the high figure in June of 1959—11 years ahead of schedule.

Again, the failure of the 1945–46 projections was due primarily to the forecasters' inability to predict fertility accurately. You will note that the projections were prepared just before the unprecedented and unforeseen postwar "baby-boom." With the release of millions of men from the armed forces in 1945 and 1946, marriages reached a record high in 1946 and births shot up in 1947. The birth rate has been high ever since. Even in the high fertility series, the numbers of births projected for 1945–49 were 18 percent too low, and those for 1950–54 were 27 percent too low.

Such an impressive failure of the methods then in use could not fail to stimulate a search for new methods of forecasting fertility. The most significant first step was Whelpton's development of the cohort approach to the analysis of fertility (Whelpton, 1958). With this technique, the reproductive behavior of a group of women is followed from the beginning to the end of the childbearing period. The groups considered are called cohorts and consist of women born in a given 12-month period.

The cohort approach soon revealed an important defect in the older methods of forecasting fertility rates. In the projections referred to previously, future annual fertility rates were extrapolated from past annual rates on the assumption that the future would not depart radically from a relatively simple extension of past trends. The medium fertility assumption in the 1945–46 projections, for example, was that birth rates at each age would resume their long-time downward trend after the brief upturn observed during World War II. Cohort analysis demonstrates clearly that past changes in annual rates by themselves do not provide good indicators of future rates, simply because fluctuations in annual rates are so strongly influenced by *when* women have births rather than by how many they will have eventually. This holds true for such sophisticated measures as gross and net reproduction rates.

We now know, for example, that many of the women who reached the beginning of the reproductive period in the 1930's delayed marriage and, if they married, delayed childbirth during the depression and war years only to make up for most of these postponed marriages and births during and after the war when economic conditions and marriage prospects were more favorable. In addition, after the war women married at younger ages than formerly, and we have good reason to suspect that they are advancing their births to the early years of marriage and that they will have fewer births in later years of marriage than was commonly the case for previous generations.

In other words, the annual rates of the 1930's were low in large part because of the postponement of marriages and births. Those of the late 1940's and the 1950's are high partly because of the advancing of marriages and births that would ordinarily occur later.

Variations in eventual family size have been of less importance than these variations in timing in determining the trend of annual birth rates.

It became apparent, then, that projections of births might better be made on the basis of assumptions about how many of the women in each cohort will marry, when they will marry, how many births they will eventually have, and when they will have them. Past developments indicate that the most important unknown in this equation, for long-range projections, is eventual family size. How can we make a good guess about how many children women will eventually have?

Here we come to the second important forward step in fertility analysis in the postwar period—a study known originally as the Growth of American Families. In this venture, the Scripps Foundation staff joined Ronald Freedman and the

Survey Research Center of the University of Michigan. Under their direction, a national sample of white wives, 18–39 years old, was interviewed in early 1955. The purpose of this survey was to discover married couples' hopes and plans for future childbearing, their physiological ability to bear as many children as they wanted, and their success or failure in limiting their family size to the desired number. The findings of this study have been published by McGraw-Hill in a book called *Family Planning, Sterility, and Population Growth*, by Freedman, Whelpton, and myself. In the remainder of this paper I shall present a brief summary of our findings with respect to family size and population growth.

In the first place, we found that American women do not expect to have large families. Most of them expect to have two to four births. The average is about three for women who recently began their childbearing. This does represent a rise over the family size of women who have recently completed their families, however. The broad historical picture for all women (white and non-white) is this: women who were born in the early 1870's and who married and lived to the end of the childbearing period, had about 4.4 births on the average. This average declined to a low of 2.4 births for women born in 1906–10. Later cohorts have already surpassed this low, and the most recent cohorts for which we have data will probably have an average of about three births per married woman living to middle age. The latter figure is a medium guess based in large part on the replies of the women in our study.

On the basis of our study information and cohort fertility tables, we prepared three series of population forecasts to the year 1980.

The low series is based on the assumption that only 90 percent of the women in the more recent cohorts will marry, that the completed family size of those who live to middle age will be 2.5 births, and that the ages at which they marry and have babies will be later than has recently been the case.

The medium series is based on the assumption that 94 percent will eventually marry, that they will average three births, and that the timing of migrations and births will be about the same as recently observed for younger women.

The high assumption is that 98 percent will marry, that they will have 3.3 births, and that the tendency to marry and have births at younger ages will continue.

We do not expect that any of these assumptions will describe with precision the future course of fertility, but we do hope that we have bracketed the trends that will develop and that the medium assumption will approximately describe the central trend around which deviation will occur.

Our assumptions about the future course of mortality and migration were borrowed from the United States Government. The mortality assumptions allow death rates to decline to levels considered probable by experts in the Department of Health, Education, and Welfare (Greville, 1957). The migration assumptions allow for an annual influx of 240,000 people, in accordance with projections prepared by the United States Census Bureau in 1955 (Bur. Census, No. 123, 1955). This volume of net immigration is somewhat lower than the average observed during the 1950's. We do not expect deviations from these assumptions to have much effect on the accuracy of our projections. We are, of course, specifically leaving out of account the possibility of an atomic war.

Before preparing our projections, we allowed for an estimated undercount of 5.5 million in the 1950 census. This is not an official figure, but one that was arrived at after careful analysis by Ansley Coale at the Office of Population Research at Princeton University (Coale, 1955). Please keep in mind that this adjustment makes the projected figures I cite about 3.3 percent higher than figures consistent with Census Bureau estimates.

Starting with an estimated population of 170.7 million in 1955, our projections for 1980 are as follows:

Fertility Assumption	1980 Population	Percent increase since 1955
Low	215×10^6	26
Medium	239×10^6	40
High	262×10^6	54

The year 1980 was as far as we cared to extend the low and high assumptions because we considered that they represented extreme conditions that were not likely to prevail for very long if they were approached at all. However, we did extend the medium series to the year 2000, and this calculation gives us 312 million. If this figure proves correct, the total population will double in the last half of the century just as it did in the first half. Over the whole century, our population will have increased by a multiplier of four.

Realizing that there are many people, like those present, who are interested in long-range population prospects from the point of view of planning the development and use of our natural resources, we made some rough computations for the year 2050. Extending our medium series that far into the future would increase the United States population to 575 million, or over three times as many people as we have now. This emphasizes the fact that fertility need not be high to obtain rapid population growth. The average of three births per family, on which this forecast is based, is certainly not high from the point of view of a human potential of nine or ten births on the average. It seems reasonable in terms of the experience of ourselves and our friends. Yet, the implications of the continuation of such moderate fertility leads eventually to population totals that may easily frighten conservationists. By way of illustrating what *could* happen, I might add that if we extended our *high* assumptions of 3.3 births per family to the year 2050, we would obtain a population of nearly one billion.

Coming back to what is often erroneously called the foreseeable future, I should like to present briefly some of the more visible population trends in the years ahead.

In the first place, the birth rate seems likely to decline in the next five years or so, not because of any reduction in completed family size, but only because of the advancing to the 1950's of births that would ordinarily have occurred in the 1960's. This decline will not occur if our high assumptions prove to be more accurate than our medium assumptions. Our medium forecasts show a birth rate of about 20 per 1,000 in the 1960's, as compared with about 24 in the 1950's. So, if you see reports of declining birth rates in the next few years, don't write off our long-range forecasts as improbable. We can expect wide fluctuations in annual birth rates in the future because most people have learned how to control not only how many children they will have but also *when* they will have them.

If our medium assumptions are correct, the birth rate will probably vary around a level of 20–22 for the rest of the century. The low assumptions indicate the possibility of decline to 15–17. Only the high series yields a continuation of the high rate of 24–25 experienced in recent years.

What will happen to the size of the school-age population? The number of children eligible to attend elementary school (grades 1 through 8) is now increasing rapidly and will continue to increase up to 1965. At that time the age group 6–13, which includes the large bulk of those enrolled in elementary schools, will contain approximately 32 million children, as compared with only 25 million in 1955. Thus, the problem of how to increase the capacity of our elementary school system as rapidly as the number of school-age children rises will continue for several more years.

After 1965, however, the elementary schools should enjoy a respite from the pressure of a rapidly increasing child population. If our medium fertility assump-

tions prove to be approximately correct, the number of children 6–13 years old will change little between 1965 and 1975. Actually, the medium series shows a slight decline in this 10-year period.

After 1975, however, the pressure on the elementary schools will again rise, as the result of an increase in births expected to begin in the late 1960's. This rise is expected as a result of an increase in numbers of young parents. The medium series shows the number of children 6–13 years old constantly rising after 1975 to 45 million by the end of the century—80 percent more than in 1955. Such a long-range forecast is, of course, highly speculative.

Children of high-school age, taken here as 14–17 years, will continue to increase until 1975. By the latter year there will be 16 million such children surviving from babies already born, or two-thirds more than the 9.5 million in 1955. Present high-school facilities will have to expand considerably to handle this increase.

Between 1975 and 1980 the population of high school age will decline by about 1.3 million, if marriage and fertility patterns stabilize during the next few years, as postulated in our medium projections. After 1980, the medium assumptions yield a steadily rising number in the age range 14–17, reaching 21 million by the end of the century. This is over two times the 1955 population in this age group.

The high fertility projections indicate that the population of high school age could reach 19 million by 1980, whereas the low assumptions show only 11 million by that time. Both forecasts are regarded as unlikely extremes.

The 4-year age group, 18–21, is critical for several institutions in our society. It includes the bulk of college students and a large proportion of the people looking for their first job and starting new households. The number of persons in this age range is virtually certain to increase from 9 million to about 16 million between 1955 and 1975, a rise of over 80 percent in only 20 years.

This rise will certainly tax the colleges and will very likely strain the ability of our economy to absorb new workers. At the same time, however, the increasing numbers marrying and entering the labor market will mean more new consumers for important products. They will want houses, automobiles, and the many other goods and services on which our economy depends. Whether the net effect of the rising number of young men and women will be to stimulate the economy by creating more consumer demand or depress it by glutting the labor market, remains to be seen. All we can say now is that a very large increase in the population 18–21 years old will occur and will very probably have an important effect on the economy. The most rapid rise is expected from 1965 to 1970, when the number of such persons very probably will jump from 12.5 to 14.7 million, or by 17 percent in only five years.

The population of working age 18–64 is virtually certain to increase from 99 million in 1955 to 127 million in 1975. The most rapid gain in the 18–64 age group will occur in the 10 years between 1965 and 1975, when the number increases by 18 million, or 17 percent. This rise is due primarily to the much larger number of births during 1947–57 than during previous years.

After 1975, the trend in the number of persons in the working ages becomes less certain. By 1980, it could be as small as 133 million or as large as 138 million, according to our low and high projections. If fertility in future years follows the trend described by our medium assumptions, the number in the 18–64 age group will continue to increase fairly rapidly in the last quarter of the century. The medium forecast for the year 2000 is 176 million, which is 78 percent above the 1955 figure.

People of retirement age, taken here as 65 years old and over, constitute one of the most rapidly and steadily growing age groups in our population. Between 1955 and the end of the century their number will more than double, increasing from 14.7 million to 31.9 million. This is a rise of 117 percent, which is considerably above the rise of 83 percent expected for the total population according to the medium series.

In summary, if present family growth plans are continued and realized, the American population will grow rapidly although there may be important troughs and crests in the growth curve. The moderate families Americans expect will produce substantial population growth if present marriage and childbearing patterns persist. This growth will occur even if there is no significant reduction in mortality and little or no immigration. That *large families are not required for large population increases* may be one of the most important conclusions to be drawn from the projections prepared for this study. With little change in mortality, marriage patterns, or immigration, the three-child family would lead to a population of 312 million by 2000 and of nearly 600 million by 2050. Projecting the same assumptions for another century would lead to astronomically large population figures. Even *the forecast for the year 2000 means a population so large as to imply a fundamental change in many aspects of our society.* Americans may soon have to choose between the consequences of a very large population or a revision of their present values about marriage and childbearing.

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WILL WE HAVE ENOUGH FOOD AND FIBER?

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The question, "Will we have enough food and fiber?" is perhaps the simplest of those discussed at this symposium. If the question had only specified "WHEN?" I think it could be answered in one word, "NO," though that would hardly be helpful.

At a time when we have in storage almost an entire year's crop of wheat, when the face of the Midwest is dotted with cribs bulging with stored corn, when similar stories can be told for practically every food product, it may seem absurd even to raise the question.

So far as food supplies for this country alone for the next 25 years are concerned, it *is* absurd to raise the question. If in some gigantic migration another hundred million people should be dumped into our land tomorrow, we could feed them. They would not eat steak, but they could be fed, and nutritionally well fed.

Ten years ago Dr. Firman E. Bear, then president of the American Society of Agronomy, gave as his presidential address "Food for Thought about Food." In this he summarized what we knew at that time about the possibilities of expanding supplies.

I wish to summarize just a few of them to suggest the possibilities: (1) The greater use of fertilizers can produce increases in food production almost beyond imagination. This is, indeed, the source of today's surpluses. We have less land in corn today than we had 50 years ago, though we produce much more today. (2) Higher yielding crops produce similar results; the development of hybrid corn increased the potential yield by more than 20 percent. (3) We can put crops on land that is not now in crop production, in the southeastern part of this country, by irrigation, in the world by developing use of tropic lands. (4) An important share of our present production is prevented or destroyed by weeds, insects, and plant and animal diseases. These are being rapidly controlled by chemical and other means. This has led to important increases in food production and will continue to do so. (5) We are conserving water, both in the arid and in the humid regions, to an extent not previously dreamed of. The mere matter of a monomolecular film on irrigation reservoirs in the West to reduce evaporation will save enough water to produce food for many thousands of people. (6) We are controlling erosion, which is still, despite what we have just heard of the taking of good land out of production by cities and industry, the most important destroyer of our productive capacity. (7) Desalting of brackish water, and even of sea water as a means of producing additional water for irrigation is now almost within economic possibility and may be within economic possibility if food should become really short. (8) The yields of human food by hydroponic methods, particularly if yeast, or algae, or both are used, are tremendous. (9) The enormous areas of the sea can produce much larger amounts of food materials than they now do, including, but by no means limited to, fish.

Twelve years ago, another Ohio agronomist, Dr. R. M. Salter, at that time head of the Bureau of Plant Industry of the United States Department of Agriculture and later the distinguished head of the Soil Conservation Service, estimated in a talk before the AAAS the possibilities of feeding the world, not merely the United States, in 1960. In a brief but careful review of the world's food supply, he estimated that we could take care of the prospective population by 1960 without any addition to our crop land, a prediction which, now that we are practically at 1960, is being overfulfilled. He then went on to estimate what could be done in the world as a whole, if we added the additional crop land which is available in the world as a whole, and carried out at least a considerable share of the additional means of food production which I have just outlined. He came up with an estimate which he put in figures and I am putting in words, that the world could support at least twice its present population, using what we knew in 1947. Obviously, Dr. Salter was assuming that the world will be a sane place, free of war, in which the maximum amount of food can be produced and distributed for human good. In practice I fear that this ideal will not be reached, but it is the only basis on which we can estimate.

I have no reason for disagreeing with Dr. Salter's estimates. They are as reasonable as can be made with so many imponderables.

Malthus, about 160 years ago, predicted that mankind would die of starvation. It has been fashionable to hold Malthus up to ridicule and tell how completely mistaken he was. Malthus certainly underestimated the ability of science to solve our food problems. If we were to estimate today the maximum population for which we could produce food, it is probable that we would similarly underestimate the potentialities of science.

But that is of comparatively small importance for two reasons. First, in many parts of the world today the pressure of population on food supply is of immediate and pressing urgency, and it is a desperate question whether these countries will have time or resources to apply what we and they knew. China, for example, an already overcrowded and underfed country, is at present experiencing a "great leap forward" which may, said the same Dr. Bear, be resulting in a population increase as high as 30 million a year!

Second, the basic fact is that despite the ridicule, Malthus was everlastingly right. How we must answer the question, "Can we have enough food to feed the world's population?" is entirely a matter of timing, whether you are talking about the near or the far view. If you ask whether we can have enough food for the next 25 years, the answer is obvious; we can. If you ask whether we can have enough food 100 years hence, the answer is not so obvious.

We have today a population base approaching 3 billion people. You can make any assumption you please as to the ability to mankind to produce food. We have only to carry the world's population increase a few more years to exceed any possible estimate of our food supply. At the *medium-level* projections of the United Nations study, we will reach 6 billion by the year 2000, which many of us will live to see. That would take all of Dr. Salter's estimated world food production protential.

Even a very small percent of increase on *our present population base* can produce more people than we can produce food for. To exceed our productive capacity merely requires that we continue the increase for another 10 years, for another 50 years, or another 100 years. But what is even 100 years to the length of time that man has been on this planet? And when you remember that any attempt to control population is a matter which goes contrary to our deepest instincts and will therefore probably require centuries of change before we really accomplish it, it is not a moment too soon to be thinking about means by which the percentage of increase in world population can be brought to zero. Zero increase is the only possible and logical answer to population problems. If there is any continuous increase whatever in population, it will, sooner or later, lead us to destruction. Our great hope is that our splendid present capacity for increase in production may give us time to learn to live like human beings instead of animals.

Ecologically, the numbers of any species of animal are mainly kept in balance by: (1) predators, (2) diseases, and (3) starvation. For man the only predator of any importance population-wise is man himself. We now have the capacity to wipe out the population of the earth, if some madman desires to do so, and that possibility is the only problem of more importance than the population problem. A basic reason for the present population explosion is our increased control of diseases. In the United States our control over diseases is now so great that an average of only three births per family will yield a population of 575 million by the 2050, a rate of growth we are now markedly exceeding. We can, therefore, leave disease out as an effective population control from here on. That leaves starvation as the only final control of human populations *except for the use of our intelligence*. We are tremendously fortunate that our food supplies are capable of being increased to the great extent that they can be. That capability gives us hope that in the time thus given us, we can learn to prove that intelligence can, in practice, lift us above the animal ecology.

CAN TECHNOLOGY SOLVE THE MATERIALS NEEDS PROBLEM OF THE WORLD?

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As I search for the answer to this question I am reminded of the young engineer who, as he was pondering over an intricate problem of engineering, was asked, "Are you working on the solution to the problem or are you a part of the problem?" That is the question each of us may be asked as we are pondering over the issue of population pressure and the problems that relate thereto. We are part of the problem; this makes objectivity difficult.

I propose to demonstrate to you that technology can supply the materials-needs for the present population, and even for a higher population, for several hundred years, but that serious problems confront us in the next century even with the present population level. I shall also suggest what could be our potential food supply in the next thousand or several thousand years.

Some limitations we face in the near future.—Let us first consider some of the serious limitations, as well as some of the adequate resources, and some changes in materials that we can anticipate in the near future. Presently the rich ore deposits and fossil-fuel supplies are rapidly being depleted or nearing exhaustion. For several hundred years the energy resources of atomic and solar energy should

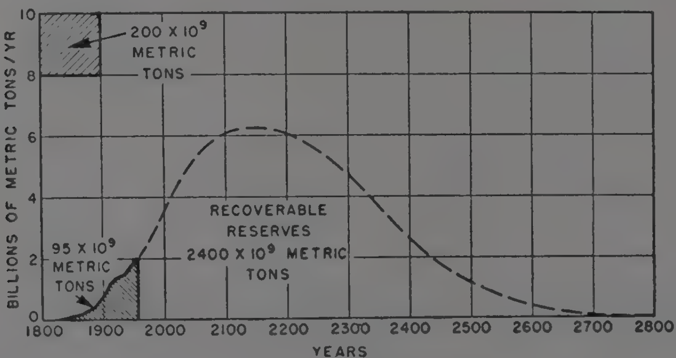

FIGURE 1. Ultimate world coal production (Brown, 1957).

be abundant. However, our technology will be considerably modified because of the limitations of the only available or reasonably priced metals. This may impose a serious limitation on our food and clothing supply. Most of our articles of clothing will be synthetic. Food can be plentiful if we are willing to modify our diet considerably and can work out effective methods of distribution. It is difficult to predict how long we can continue to supply food, fuel, and clothing because of our limited knowledge of such simple problems as the continued supply of phosphorus for fertilizer, or our ability to utilize solar power to concentrate atomic fuels (an extended use of water power) for this purpose.

These are some of the problems you must consider as you project your thinking into the future—beyond the next 100 years.

The rise of techology. In 1850, 94 percent of the heavy work in this country

was done by man and 6 percent by machines; in 1950 these percentages were reversed. This gives us a picture of the rise in technology in the United States in the last 100 years. This is quite significant because it does infer tremendous changes in our mode of living through technology. It is said today that 50 percent of the jobs in the country can be traced back to research laboratories where the discoveries are made which make it possible to develop technology (Meier, 1956).

This background becomes an important factor as we consider what our technological potential is and how we are making use of it in the country. Once we have the know-how and our citizenry is organized to make use of it, the question you will be concerned with is whether our technology will have materials to use—the natural resources, the fuels, and the materials to produce our machines, our food, our shelter, and our fuels.

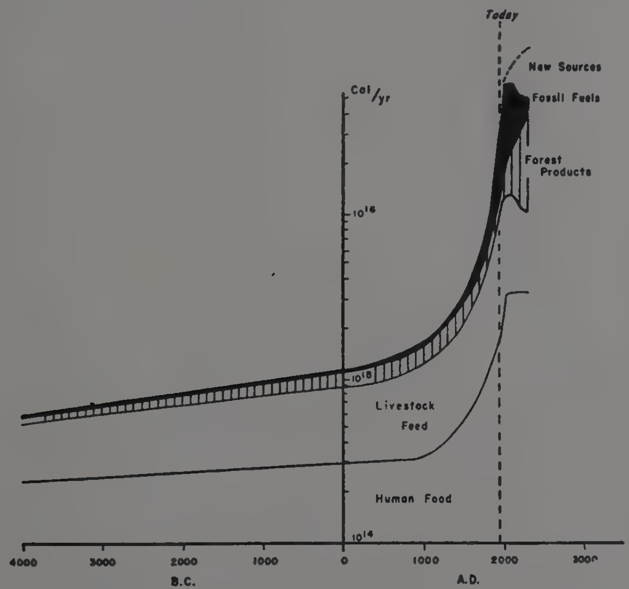

FIGURE 2. Energy use over historical time (Meier, 1956).

The fuel resources.—We have already consumed a tremendous amount of our world fuel supplies. In the United States very likely we have consumed more of our total natural resources in the past 50 years than did the whole world in the previous 50 centuries. There is a tremendous demand on our resources as a result of the increase in technology.

Figure 1 indicates that some place in the period around 2100 or 2200 A.D. we will go through the maximum consumption of fossil fuels.

If you are projecting your ideas about available resources beyond 1000 years, you realize we run into very serious resource problems. For example: We have about one-half of the world's coal supply in the United States and it is estimated that somewhere around 2200 we'll run through the peak of production in the United States. The rest of the world may continue to use coal for a longer period because they are not now using it as rapidly as we are. However, there is certainly

a definite period within the next 1000 years when our rich fossil fuel supplies will be depleted (Brown, 1957; Hubbert, 1949).

The petroleum reserves. –The petroleum reserves are very difficult to predict. It is very likely that in about 50 years most of our rich petroleum supplies may be depleted. In several states in the United States we have gone through the peak of production already.

Efficiency in use of fuels. Figure 2 gives pause for concern with reference to the raw materials that technology must make use of in producing food and clothing. For a long time there was very little change in the kinds and the amount of fuels including food and livestock food. But you see that since 1800 this increase has been tremendously dramatic and it continues to go up. That is a very disturbing fact to peoples of the world today.

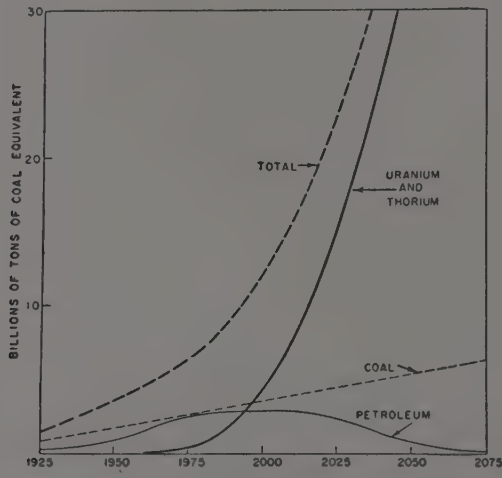

FIGURE 3. World energy consumption in the next century – a possible pattern (Brown, 1957).

Energy resources other than coal and oil.– If our fossil fuels are depleted, you may raise the question "What's the possibility of other energy sources?"

Of course, the best source, if we could use it effectively, is solar power. It is very likely that within the next 50 or 100 years we will make considerable progress in trapping solar energy; but until that comes about, we'll be using nuclear fuels. Figure 3 shows you about the time that atomic fuels will be used heavily. It is estimated that about 1970 atomic fuels will be in favorable competition with fossil fuels. And when the the cost curve for atomic fuels goes below that for fuels for steam power to make electricity, you will find a tremendous development of atomic fuels in place of coal and oil. When that comes about, the curve with reference to the rate of use of fossil fuels will change considerably. The use of atomic fuels will change considerably. The use of atomic fuels can extend the life of our fuel reserves by a factor of about twenty. If we can use the nuclear reactor using hydrogen and other light elements, we can extend fuel resources almost indefinitely.

The fuel problem is one that can be taken care of and we can have fuel supplies for a very long time.

The growth in the world's population.—Figure 4 gives the rate of increase in the population of the world.

In figure 5 we find the possible projections of the world's population to year 2000 and extrapolated to 3000 and 4000 (with uncertainties represented by the area between the branched extrapolations.)

When you compare graphs of the sort with the ones for fuel consumption, you can see they are almost superimposable.

Figure 6 shows the rapid increase in population of the United States.

Our natural resource reserves.—The really critical items as far as materials-needs are concerned are the ores as sources of metals. This is a fact most people do not recognize. They think in terms of food instead of in terms of metals to make the machinery help to raise and transport the food. This is the critical and startling part of the whole story.

The high grade iron ores in the United States will be exhausted in the next 100 years. The medium grade iron ores may last at the present rate of usage about 300 years.

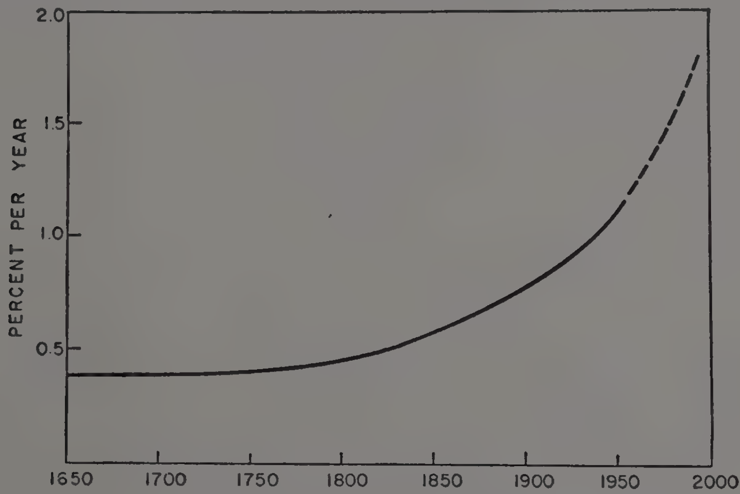

FIGURE 4. Annual rates of increase of world population (Brown, 1957).

Rich aluminum ores run about the same as iron in abundance. Rich oil reserves are limited. We import roughly half of our aluminum ores at the present time. It is true that ordinary clay contains 6 to 8 percent aluminum; if economical methods to extract it from clays can be developed, we have enough aluminum ore to last a long time; but it is very expensive to make metal from ores of low concentration. You can afford to do it for an expensive metal such as copper. We are now extracting copper from ores as lean as 0.3 percent (Brown, 1954). The magnesium reserves are much better than aluminum. We now extract all the magnesium we use from sea water. It can be extracted from brines which represent a very large reserve.

But here is the rough spot, iron and oil are our main materials for today's technology and these materials are severely limited.

How much food can the world produce?—Assuming fuel supplies and metals are available for manufacturing the machinery necessary for food production,

table 1 gives some projections from Harrison Brown (Brown, 1957) with reference to amount of food that can be produced. This answers what technology can do for food production. More lands can be put in operation. Algae farms can be used. The productivity per acre can be increased. Brown's summation is that

TABLE 1

The World's Estimated Food Potential (after Brown)

Existing food production (given a base rating)	1.0
Production possible from existing land, using known conventional agricultural techniques	1.1
Production possible from existing cultivated land plus 1.3 billion new acres of tropic and northern soils	2.0
Production possible from existing land, using supplemental irrigation of 1 billion acres now under cultivation and complete irrigation of 200 million acres of desert and near-desert land	2.0
Production possible from all above sources	3.0
Production possible from above sources plus increased yields due to improved plant-breeding and selection and foreseeable improvements in agricultural techniques	6.0
Production possible from 100 million acres of algae farms	2.0
Production possible from all sources, including 1 billion acres of algae farms	25.0

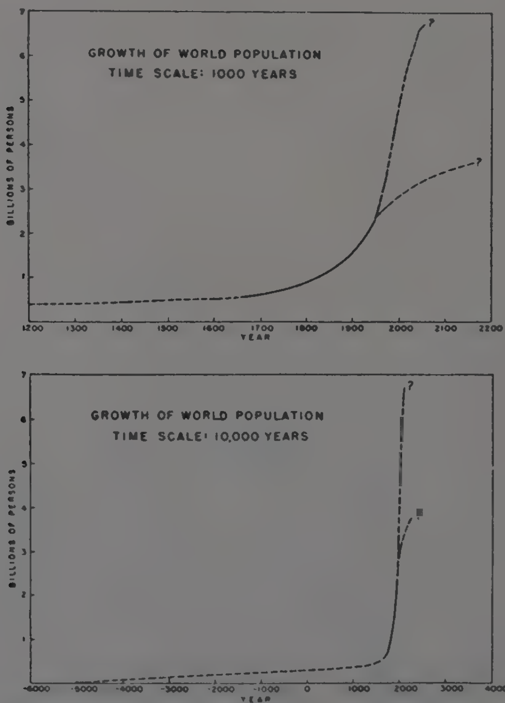

FIGURE 5. Growth of world population (Brown, 1954). Time scale: 1,000 years (top). Time scale: 10,000 years (bottom).

food production, utilizing all conceivable means, could be increased about 25-fold. Brown's estimate is simply what technology could do if we have adequate fuels, metals, and fertilizers. This 25-fold increase is simply the upper limit of what technology could ever achieve.

But what other problems must be faced?—If you think of the present world population of 2.5 billion to which sufficient food is not available (even in spite of great surpluses in some areas) because of major problems in distribution resulting in two-thirds of this mass of people going to bed hungry every night, you can prepare yourself to consider some of the great problems facing the world if the population doubles. We can expect many problems other than just raising the food. Furthermore, many of our foods may have to be changed radically. We may have hamburger sandwiches made of algae; "wheaties" made of sawdust fortified with enzymes (man doesn't have enzymes to split the cellulose to glucose); —a whole series of new developments of that sort are feasible. However, there are

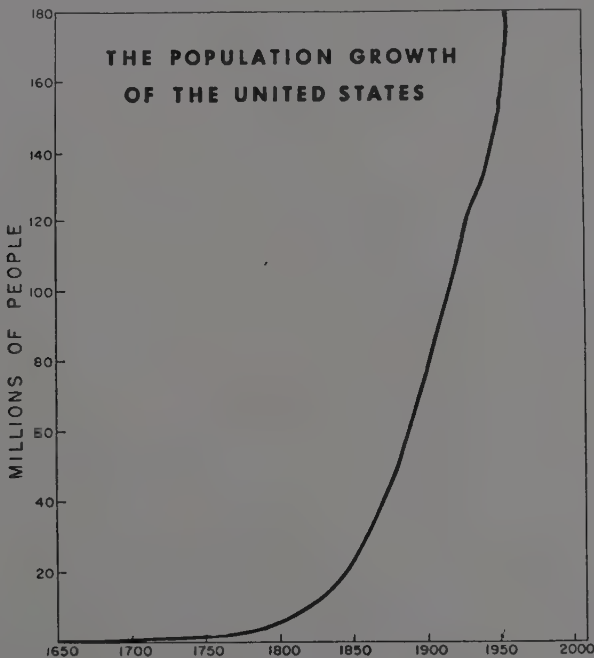

FIGURE 6. The population growth of the United States.

other limitations that must be considered when you think even of doubling let alone of quadrupling human populations. These limitations are not now necessarily in raw materials but rather they involve the human factor. Brown says, "If we are willing to be crowded together close enough and eat foods which bear little resemblance to the foods we get today and be deprived of simple and satisfying pleasures such as fireplaces, gardens, and lawns, a world population of 50 billion persons would not be out of the question.

"If we really put our minds to the problem, we could construct islands where people could live and algae forms could function, perhaps a 100 billion people might be possible.

"If we set strict limits to physical activity so calorie requirements could be reduced to an absolute minimum, perhaps as many as 200 billion persons could be possible. Again this is consistent with active data as far as technical requirements are concerned."

Solution to the human factor limitation.—McKelvey (1959) points up this problem in the following statements: "Resources of usable raw materials and energy may be increased to an unpredictable extent by the development and use of *ingenuity*. The most fundamental stimulus to ingenuity is the basic idealogy that challenges, encourages, and rewards individual initiative, gives freedom of thought, creates a desire for economic gain and a thirst for knowledge."

Summary.—The recent rapid development of technology in our own country is good evidence of the possibility for continued development and effectiveness of technology for the future.

All things considered, a factor of 25 seems to be the extreme upper limit which is conceivable for the future as far as food production is concerned; the world population might go to 200 billion but more likely 100 billion is the maximum possible limit.

The limiting factors for the next hundred are not the materials-needs factors alone but the social, political, and economic factors. These are the major ones for any increase in the world population.

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WHAT EFFECT HAS POPULATION GROWTH ON PEOPLE?

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When I was a child, there stood in the corner of our living room a small rack of shelves that held most of our books. Among these was a dingy, dark-bound volume of sermons of the vintage of the middle 1800's. One discussion that interested me especially was a discourse upon whether on the day of judgment there would be a resurrection of the physical bodies of all mankind that had lived and died until that time. The opponents claimed that there wasn't room on the earth for all these people to stand on the day of judgment, but the parson who was giving the sermon calculated that, during the lapse of time since Adam and Eve were driven from Eden and their offspring cursed because Eve had misappropriated an apple, only enough human beings had existed to allow three square yards of land space per person and that, therefore, it was completely possible to have physical resurrection. This was about 100 years ago. Since then the world population has increased one and one-half times. At this rate, only about one square yard per person is left (and if this old preacher's calculations were correct, I suspect the Lord will have to hasten His return or there will not be enough land for all to stand on.)

Now of course, such discussion is as pointless as the medieval arguments about how many angels could stand on the point of a needle. Therefore, we might better turn our attention from what will happen to the dead to what will happen to the billions that are yet unborn.

We have had presented in preceding papers, and you can readily find elsewhere, many statistics upon the past, present, and probable future rates of reproduction and population growth among mankind in various areas of the earth. There is a great deal of speculation as to what will happen in the next 50 years. Much of this speculation will be changed slowly, but inexorably, from speculation to reality. As long as it is speculation we will have those who see only hopeless disaster and also those who naively believe that man can surely rise to every emergency and always win. Has man's past demonstrated the acceptability of this belief? Does his present condition throughout the world warrant it?

It is only natural in a country such as ours that the flush of youth, success, and plenty should dominate much of the thinking on social problems. When we believe that we can't lose, we fear nothing. When we believe that we have an endless supply of anything, we usually waste it. My father once told me of a trip which he took by horse and buggy when he was a young man. Riding across Indiana he passed through areas where natural gas had recently been discovered. Almost every barnyard had an iron pipe protruding into the air with no shut-off. Gas escaped in great jets. It was lighted and burned 24 hours per day, inexhaustible light and fuel that cost nothing. Have you paid your gas bill recently? He also told me that when he was a boy he could go out after dark armed with a club and knock off of a rail fence in a short time enough passenger pigeons for the next several day's food. Countless millions of these pigeons blackened the skies for miles. The last living specimen died in the Cincinnati Zoo in 1914.

I would like to call your attention to a few examples of experimental work which are rather basic and perhaps not too widely applicable but which have some meaning with regard to populations. If you have made cultures of microorganisms in the fashion that you know as the "hay infusion," you have collected dead grass, leaves and sticks from low spots on the ground, put the material in a battery jar, and covered it with water (fig. 1, A). If you examine this material daily, for the first few days you find almost nothing in the way of microorganisms, but by the end of a week you find that nearly every drop of water has a number of organisms in it. By the end of two weeks it is swarming with organisms and they seem to have been developed out of a few types because they are nearly all of the class we call Ciliates, very largely Paramecia of several species. The population is unbelievably crowded. If you continue examining it for three weeks, you find that the water has cleared considerably, a great many of the kinds of organisms have disappeared, and those that remain seem to have adjusted to what appears to be a reasonable sort of population pressure (fig. 1, a).

Similarly, the well-known fruit fly, *Drosophila*, that is cultured for experimental work is grown in half-pint milk bottles (fig. 1, B) and there is a culture medium placed in the bottom. If you add to such a jar a pair of friendly *Drosophila*, they will proceed to populate the bottle. The population follows a typical sigmoid curve of population growth (fig. 1, b).

Now, if in such a culture you start with twice as much food, (fig. 1, C) we find a similar curve of population growth and not a very different one in numbers (fig. 1, c). If, on the other hand we start the culture in a different kind of a jar which has several times as much exposed area, we find a curve which rises more rapidly because it produces many more flies although the total amount of food is no greater than in the first bottle. This seems to indicate that things of this kind bear a very definite relationship to the availability of necessities; that is, the growth of population is certainly directly related thereto.

Frogs and fish and flies and birds and microorganisms are quite different from

man. But are a protozoan and a dog more alike than a dog and a man? It is an undeniable fact that man's chief distinguishing asset is his vastly superior intellect. While man has developed this intellect during the past one-to-two million years, we can scarcely overlook the fact that many kinds of organisms have survived for hundreds of millions of years with almost nothing comparable to intellect. During the past half million years many kinds of human or near-human organisms are known to have existed. Some say they were different species, some say not. If they were anything but human, I'm sure they would be called different species. Whether human or not, they have become extinct. Why? Is only *Homo sapiens* smart enough to survive? Will he not destroy himself? What guarantee have we that intellect will offset the responses of protoplasm to the inexorable natural laws?

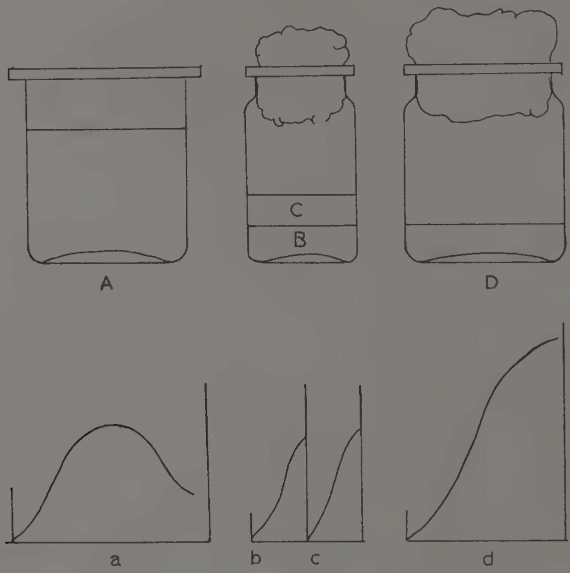

FIGURE 1. **A,** culture jar for protozoa; **B, C, D,** culture jars for *Drosophila*; **a,** population curve in protozoan culture; **b, c,** population curves in drosophila cultures with same surface areas; **d,** population curve for a drosophila culture with larger surface area.

Wherever we look at living things we find that their problems of existence are different from each other's in detail but alike in principle. The clam and the starfish live side by side in the sand at the bottom of the sea. The clam will not harm the starfish but the starfish will eat the clam. If enough starfish are present, they will nearly destroy the clam population. Then they will begin to starve and their numbers will be decimated. Because of the fewer starfishes more clams will survive and the clam population will rise again.

Those pioneers who moved away from the Atlantic seaboard, struggled over the Appalachian highlands and floated down the streams into the great wilderness faced great hardships. Only the mentally alert and the physically rugged survived. There were strong selective forces. From these stalwarts descended the people who were to lay the foundations of the great Middle West. The same

selective forces do not operate in the same manner today, or at least, not to the same extent.

Let us look for a moment at a graphic representation of the history of human culture and the growth of world population. This graph is not based on any particular set of statistics. It is only a crude diagram of some of the chief phases of man's history. I have used two lines, one to show human population growth, the other to show the development of man's culture. We might present these as a succession of eras:

1. If we go back into pre-history, about which we know very little, we might assume that in the early days with relatively few human beings and a great many hazards the population went up and down, that it probably came close to extinction at times and flourished at others, varying according to availability of food. This is Period 1 on the chart (fig. 2), an era of primitive struggle for survival.

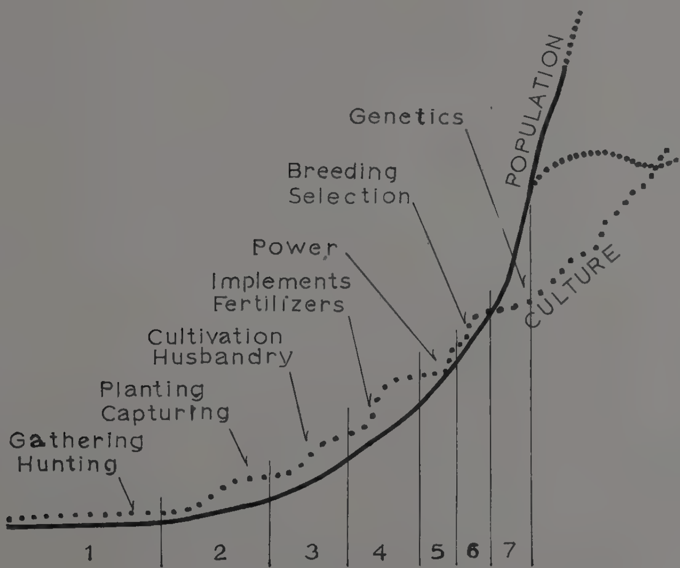

FIGURE 2. Human culture and population growth.

2. The second era, where planting and capturing came in, must have developed because some persons observed that seeds gathered for food and later thrown away, grew. They then found it was possible to have close at hand, foods for which they once had to forage. Also it must have been discovered that some kinds of animals could be confined and thus be available for food over longer periods of time than if they depended solely on hunting. These developments led to the concepts of planning ahead and of cooperation. This is Period 2.

3. The third era, labelled cultivation and husbandry, is one resulting from the discovery that it was possible to do a little tilling, to get rid of weeds, to prepare soil, and thus to plant and grow food. Also it was discovered that some animals could be kept in captivity, could reproduce in captivity and then assure a greater supply of food for a still longer period of time. Period 3 is thus an era of of the first true agriculture, and the basis of civilization.

4. Period 4 is where implements and fertilizer became rather widely used. Sometimes this is referred to as the birth of civilization; education, culture, social stratification with division of labor, and consequent conflicts.

5. Next there was added to man's activities the application of power; power of some kind or other, mostly from animals, power from horse, camel, dogs. This was a long period which has only recently terminated in some parts of the world. One might well wonder what man's civilization might have been like had it not been for such animals as the horse. With this period, technology began to develop, population grew though slowly. A close balance between populations and food supplies appears evident.

6. Then came the idea of breeding animals. Not just keeping animals in captivity but breeding them and selecting the better and more satisfactory for producing offspring. That period of improving the quality of food has not yet ended.

7. Now that we understand, or are about to understand, the causes of differences in quality and quantity of food we can be said to be leaving the era of culling and selecting and to be entering the seventh era, the era of science and technology.

Already the rocket ascends. We who live in relatively uncrowded abundance can have great faith in the omnipotence of our technology. We may believe that human intelligence will meet the challenge. There is little evidence to support this belief at present. While we destroy our surpluses of necessities and squander our resources, what is happening in other parts of the world?

Within the memories of all of us, our geography books used to tell us of the tremendous populations that attempted to survive in the valleys of the Nile, the Ganges, the Yellow River, and elsewhere. The teeming millions were held in check by crop failure, pests, epidemics, floods, and sometimes by wars. Such natural controls seem brutal to our Western minds (unless we are at war); so, we feel it our sacred duty to do everything possible to prevent its happening. We send physicians and nurses to train them to prevent infant and mother mortality. We supply drugs and antibiotics to prevent loss from diseases. We send as much food and other essentials as can be transported to prevent starvation. We teach them how to care for the invalid, the insane, the aged, in order to prolong their lives. We like to do these things because it gives us a feeling of personal goodness.

If you came home from work one evening and found that the drain to the kitchen sink was partially clogged and that your wife had turned on the faucet till the water ran over onto the floor and that she was frantically trying to mop it up with a towel which she wrung out into the sink, you would probably want to stick her head in the sink. Of course, you might seize a bucket and cup and start bailing out the sink. This could help for a while but your bucket would soon fill and you'd be worse off than before.

In this little sink that we call our world the flood is on. Today it is our neighbor's sink in the apartment upstairs. Tomorrow it will run through on our heads. So far we have tried everything except to turn off the faucet. If we do try, we find that there are many other hands turning it on: tradition, taboos, religous tenants, ignorance and illiteracy. Under I.C.A. five Colleges of Agriculture in State Universities are each assigned about one-fifth of the area of India where projects are carried on in an effort to help improve the agriculture of that area. Hundreds of millions of dollars are spent by I.C.A. annually to make it possible for more people to survive. This might be a noble effort if it didn't eventually increase the problem.

Forty-four million people per year are added to the world's population; one more every time your heart beats. In ten years the increase will be something like 50 million, for the *rate of increase* itself increases.

I know that there are some who believe that God endowed Man with the

power of procreation and that interfering with it is opposing His will. He also endowed Man with intelligence enough to recognize his problems and provide against them, and if he does not use this intelligence he is equally guilty of flouting God's will. It is our custom on special occasions to wish each other health, happiness, and prosperity, yet we are also made to feel that to enjoy these blessings is some kind of sin so long as there are people in other parts of the world who lack them.

One of our solutions is to open our doors and arms to peoples everywhere. If not carefully done, this might soon spell disaster. We have been doing a lot of it recently. There are certain social and religious groups that have organizations, raise money, and use every political pressure to secure the entry of their adherents into this country. It is these same minorities who, from press, pulpit, classroom, and television, cry "prejudice" against any who think that it isn't right. Regulations regarding immigration need to be looked at carefully, and not set aside every time we feel a little sorry for somebody.

A number of years ago I walked out onto a cement walk in my back yard. I looked down and saw two dark lines across the concrete. They seemed to be moving. I stooped down and looked at them more closely and found that they were two columns of ants, one going from north to south and the other from south to north. The two columns were not more than eight to ten inches apart. I noted they were large red ants rather common to this locality, but for some reason one of the columns did not look quite like the other. On closer inspection I discovered that each of the ants going from south to north was carrying something in its jaws whereas the column going from north to south was not. I tapped one of the ants with my finger. It dropped its burden which turned out to be a black ant. Then I realized that these red ants were raiders that often capture other species of ants. Sometimes they will capture a queen ant if their own colony has lost its queen.

I followed the column which carried no load and found that it went all the way around the house to a bare spot on the corner of the terrace where I had previously observed a black ant colony. Sure enough the red ants were carrying away black ants.

Now this showed lack of intelligence on the part of the ants. Requeening their nest with a black ant queen and getting most of their work done by black workers did not solve their problem at all. In three months the red ants had mostly disappeared. The queen laid only black ant eggs and all the offspring were black; so, they took over.

What effect has population growth on people?—Have you been asked recently for a contribution to support indigent Eskimos? Have you heard a lecture upon the plight of the happy little Pygmies who live a naturally adjusted life in the jungle? Do your dollars send CARE packages to the Indian tribes of the Amazon? Not likely.

Where are the "underdeveloped" countries? Who are the "underprivileged" peoples? Wherever the populations exist out of all proportion to their abilities to produce and procure the necessities for comfortable living. *There* is ignorance, pestilence, hunger, and misery. Wherever people are well-fed, sufficiently sheltered, and adjusted to their natural environment, they are *not* underprivileged. And to disturb this adjustment by creating unsatisfied desires for luxuries is a social sin.

If it were possible to produce enough food and shelter to keep a world population of 15 billion in reasonably good health—*Why should we?* What is to be gained by crowding the surface of the earth with many billions of people? I have heard many arguments about how it is possible to do it. One would think it was some kind of a game we had to win, a game to keep alive the greatest possible number. Most of them would be urbanites living controlled existences like termites.

Natural unity and beauty would be destroyed and wildlife exterminated. The freedom of which we boast would be changed to regimentation and any serious upset in the program would bring disaster on a wide scale.

Many of the great world problems of today are ecological problems. Our inability to solve them arises out of our emotional attitudes which override our intelligence. Millions go to bed hungry every night. It has long been so. In pity we offer them a share of our abundance, and the best we have offered as a solution to their ills is an attempt to teach them how to grow more food. But with more food their populations increase and their hunger continues to grow. Will we ever teach them the true cause of their predicament and allow them and ourselves to control populations to whatever size can be properly provided for? If we do not, the whole world will become as they are.

There are hopeful signs in some small areas, such as parts of India, where governments are offering financial rewards and medical care to any male who volunteers to be sterilized after having at least two children. Contraceptives are considered too expensive. Wars, pestilence, starvation, and disease are expensive too but we indulge in them continuously. Privately supported family planning clinics are being established in some countries, but they cannot receive aid from our government because they are still considered "controversial."

The next 50 years will be the most decisive era in human history. It is very late, but if we work fast and hard enough there is still time to turn down this rocketing population curve and bring it into balance with our ability to produce. To do this we will have to reach over and turn off the spiggot in the kitchen sink.

Methods of Testing Chemicals on Insects. *Harold H. Shepard.* Burgess Publishing Co., Minneapolis, Minn. Vol. I, 1958. 356 pp. $5.00.

This book is the first volume (in a contemplated series of three) that describes methods used in studying phases of the action of chemicals on insects. Many entomologists have contributed to the volume which was under the editorship of H. H. Shepard. The topics covered by chapters and those responsible for each chapter are as follows: Surface Phenomena in Relation to Insect Cuticle, W. M. Hoskins; Penetration of Insect Cuticle, A. G. Richards; Measurement of Insect Respiration, R. Craig; Electrophysical Preparations in the American Cockroach, K. D. Roeder & E. A. Weiant; Study of the Circulatory System, R. L. Patton; Radioactive Tracer Methods, A. W. Lindquist; Resistance Studies, W. V. King; Topical Application and Injection, R. L. Metcalf; Feeding and Drinking Methods, F. W. Fisk; Dipping Methods, A. H. McIntosh; Precision Spraying, C. Potter & M. J. Way; Precision Dusting; J. E. Dewey; Testing Fumigants, R. T. Cotton; Synergism and Antagonism, N. Turner; Literature Cited and Index.

The book fills a need in entomological literature and it will be a valuable reference in the library of every entomologist who is concerned at all with evaluation, toxicity, and mode of action of insecticides.

RALPH H. DAVIDSON

Collecting, Preserving and Studying Insects. *Harold Oldroyd.* Macmillan Co., New York 1958. 327 pp., 135 figs., 15 pl., 1 map. $5.00.

This book presents a very interesting and complete account of the equipment and methods used in building up a collection of insects, and ways of studying insects. The early chapters deal with collecting and preserving—where to look for insects, how to catch them, how to bring them home, and how to keep them alive or how to kill and preserve them. The later chapters deal with methods of studying insects (including drawing and photography), classification and nomenclature, identification, and writing papers for publication. The appendices include a short list of reagents, a glossary of entomological terms, a bibliography, the addresses of a few supply houses, and an index.

The discussion of methods of collecting, preserving, and studying insects is very complete; the chapters on classification and nomenclature, identification, and writing for publication are brief but well done. The viewpoint is British, and the American reader will encounter a number of unfamiliar expressions, such as setting, carding, pointing, staging, and spirit collections. As the author states, each entomologist has his own pet ideas about collecting and preserving methods, and some of the procedures described may seem awkward or inefficient to an experienced American entomologist. However, the book is written in a very readable style, and can be profitably read by either a beginner or a professional entomologist.

DONALD J. BORROR

THE PHOTOSYNTHETIC FUNCTION OF MANGANESE AND CHLORIDE

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A careful comparison of the effects of micronutrient concentrations on heterotrophic and autotrophic cultures of various algae and aquatic plants revealed definite manganese and chloride requirements for autotrophic growth, suggesting that these elements have a specific photosynthetic function (Eyster et al., 1958). Since it is possible to produce plants which are deficient in manganese but otherwise normal, information on the photosynthetic role of manganese can be obtained by comparative studies of normal and manganese deficient plants.

One interesting result of such studies is that manganese deficient plants, which show no Hill reaction oxygen production, will still produce oxygen photosynthetically at about a third the rate of normal plants (Brown et al., 1958). This raises the very interesting possibility that there are two paths for oxygen production, one of which requires manganese and is solely responsible for Hill reaction oxygen production. Additional work has confirmed this and it appears that the major photosynthetic processes are the following:

$$ADP+H_3PO_4 \rightarrow ATP+[H]+[OH] \quad (1)$$
$$2ADP+2H_3PO_4+TPN^+ \rightarrow 2ATP+TPNH+H^++H_2O+\tfrac{1}{2}\,O_2 \quad (2)$$
$$TPNH+H^++HCO_3^-+MnCl^+ \rightarrow [CHO]+TPN^++MnCl(OH)_2 \quad (3)$$
$$H^++MnCl(OH)_2 \rightarrow MnCl^++1\tfrac{1}{2}\,H_2O+\tfrac{1}{4}\,O_2 \quad (4)$$
$$2[CHO] \rightarrow [\,(CHO)_2] \rightarrow CH_2OHCOOH \quad (5)$$

With suitable cofactors reaction 1 is "cyclic" photophosphorylation and 2 is "non-cyclic" photophosphorylation (Arnon, 1959). Reaction 2 provides TPNH and ATP for the operation of the Calvin photosynthetic cycle (Arnon, 1958; Bassham and Calvin, 1957). Reaction 3 depends on the spontaneous alkaline oxidizability of $MnCl^+$ to $MnCl^{++}$ due to liberation of OH^- when HCO_3^- is reduced to a neutral intermediate. At some more acid location, perhaps an aerobic oxidation site, the spontaneous reverse reaction 4 occurs. The reduced intermediate [CHO] forms glycolic acid, perhaps via glyoxal, in reaction 5. Reaction 3, as written, has a calculated free energy change of about zero. It is probably coupled with a phosphate energy transfer to give a reasonable rate. Reactions 3 and 4 together would constitute the Hill reaction. The rate of Hill oxygen evolution from *Chlorella* cells in a carbonate free medium is doubled in 1.4% CO_2 in argon compared to the rate in pure argon (Warburg, 1958), a result consistent with reaction 3.

Reactions 3, 4 and 5 constitute a system for oxygen production and carbon dioxide fixation which is locally irreversible because the oxidation and reduction of manganese occur at two different sites where the pH is suitable. The irreversible removal of TPNH assists the photochemical system in the forward direction.

This system constitutes an alternate path for photosynthetic carbon to the Calvin cycle. It is interesting to note that the existence of two photosynthetic fixation paths has been suspected because of pH effects (Ouellet and Benson, 1952), a colored light effect (Cayle and Emerson, 1957), and the inhibitory effect of ethanol (LeFrançois and Ouellet, 1959).

The relative importance of the two paths would vary considerably with physiological conditions. Since the Calvin cycle also produces glycolic acid (Schou et al., 1950; Griffith et al., 1959), both systems produce the same metabolic products but the proportions will be different for short time labeling experiments.

The photosynthetic oxygen production rates suggest that the two paths are comparable. Since photosynthetic growth is logarithmic, a doubling of the growth rate produces a very large difference in total growth after several cycles. Manganese deficient algae cultures show virtually no growth in a week compared to the amount of growth in normal cultures.

The proposed mechanism is supported by several kinds of experimental evidence. The spontaneous oxidation in vitro of 10^{-5} M $MnCl^+$ to $MnCl(OH)_2$ at pH 10, and its reversal at pH 7, are shown by the Electron Spin Resonance (ESR) signals (fig. 1). In the absence of chloride the reversal requires a very much lower pH. This quick reversal in vitro is not perfect but does show the feasibility of a pH controlled cycle in vivo. A light induced alteration of manganese in *Chlorella* is indicated by the rate at which it is washed out of living cells in manganese free Warburg and Burk media. There is a 5-fold increase in the light over the dark.

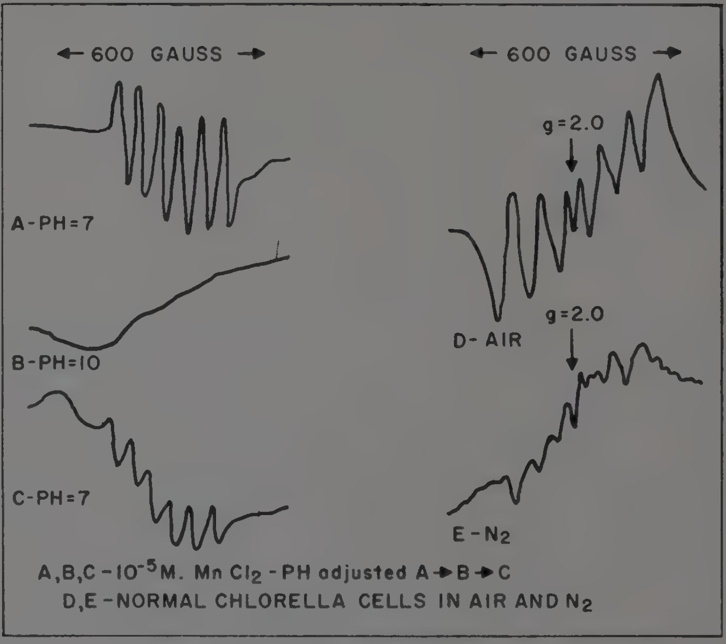

FIGURE 1. Electron spin resonance signals (ESR).

In nitrogen, the manganese ESR signal from normal *Chlorella* cells is very weak (fig. 1). Oxygen thus seems to facilitate reaction 4, probably by producing sites of low pH value through aerobic oxidation processes.

The appearance of a light induced photosynthetic free radical ESR signal is manganese dependent and the Mn^{++} signal decreases reversibly in the light (Treharne et al., 1960). This decrease occurs slowly and recovery is slow, compared to the oxygen liberation rate or the rate of the free radical formation and disappearance.

The rate of $C^{14}O_2$ photosynthetic uptake was found to be twice as fast for normal *Chlorella pyrenoidosa* as for manganese deficient cells. The distribution of products labeled photosynthetically by $C^{14}O_2$ was investigated by conventional

TABLE 1

Mn dependent $C^{14}O_2$ photosynthetic products

	Air+2% $C^{14}O_2$		N_2+1% $C^{14}O_2$	
	+Mn	−Mn	+Mn	−Mn
Glycolic acid	1050	43	202	123
Malic acid	1320	110	1480	824

Counts per minute per mg of chlorophyll. 3500 ft-c, white fluorescent light.

TABLE 2

Effect of light on uptake of C^{14} compounds by +Mn and −Mn Chlorella pyrenoidosa

	−Mn and light	−Mn and dark	+Mn and light	+Mn and dark
1—C^{14} Glycolate	19,500	18,400	78,100	23,100
C^{14} Formate	555,700	24,850	114,500	30,600
C^{14} Oxalate	271,180	3,350	75,220	3,270
3—C^{14} Glycerate	41,546	24,593	14,385	26,124
C^{14} Glyoxylate	50,500	59,400	50,200	54,400

Counts per minute/(mg of chlorophyll ×2hr).

TABLE 3

Hill reaction and photophosphorylation by sugar beet chloroplasts

	−Mn	+Mn
Chlorophyll (mg/ml of prep.)	.519	1.314
Hill Reaction [μl O_2/(hr×mg chlorophyll)]	29.	813.
Phosphate uptake [μmole /(hr×mg chlorophyll)]	24.8	17.0

TABLE 4

Reduction of TPN by Grana preparation and chloroplast extract

Chloroplast Extract Source	Grana from −Mn sugar beets	Grana from +Mn sugar beets
Market spinach	24.4	14.2
+Mn sugar beets	25.9	29.4
−Mn sugar beets	24.6	24.7

μmole TPN reduced/(mg chlorophyll×hr).

procedures (Benson et al., 1950). The results were similar to those in the literature, and were rather indifferent to the presence of manganese, with the exceptions of glycolic acid and malic acid. Both of these compounds are much more heavily labeled in normal cells than in manganese deficient cells (table 1).

The effects of light and manganese on the uptake rate of several C^{14} labeled metabolites were determined (table 2). The uptake of glycolate is increased by light and by manganese. Glycolate is first oxidized to glyoxylate (Tolbert and Cohan, 1953); hence, the stimulation is associated with an oxidation reaction. Formate, oxalate, glyoxalate, and glycerate uptakes are increased by light and by absence of manganese. These are reductive assimilations and manganese would compete with them for light induced TPNH (reaction 3). The labeled products formed from these metabolites were determined by the usual chromatographic procedures and were found to be consistent with the sequence CO_2→glycolate→glyoxylate→malate, serine, etc.

The glycolate to glyoxylate oxidation could consume all of the oxygen produced by reaction 2. This oxygen source may be physically favored and would help to keep the photochemical process moving in the forward direction. The accumulation of glycolate shows that there is no close chemical coupling between oxygen from reaction 2 and glycolate oxidation.

Glycolic acid is one of the earliest labeled products of $C^{14}O_2$ photosynthesis (Bassham and Calvin, 1957). It is excreted into the medium by actively photosynthesizing *Chlorella* and requires for its formation light, air, CO_2, and a medium with a pH above 5.5 (Tolbert and Zill, 1956). In the presence of glycolic acid oxidase inhibitor, it accumulates in tobacco leaves to account for over half of the total carbon fixed (Zelitch, 1959).

Both photophosphorylation (reaction 1) and the reduction of TPN (reaction 2) are indifferent to the presence of manganese (tables 2, 3), which is consistent with the scheme presented above.

The proposed scheme provides a rational basis for the experimental findings. Actual reaction mechanisms are undoubtedly more complex and numerous possible variations await further research. Reaction 4 may be substantially coupled with the oxidation of glycolic acid to glycolaldehyde, with some glycolic accumulating from side reactions. If H_2O_2 is available, as an intermediate from reaction 2 or from some aerobic process, it could react reductively with the Mn^{+++} compound in lieu of reaction 4. Alternatively, H_2O_2 could form a percarbonate and reaction 3 would produce an Mn^{+++} perhydroxyl compound which would decompose forming oxygen and divalent manganese.

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FOUR NEW EASTERN SPECIES OF DRUG-STORE AND DEATH-WATCH BEETLES

(COLEOPTERA: ANOBIIDAE)

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During the course of a study on the Anobiidae of Ohio the following new species were discovered:

Euceratocerus gibbifrons n. sp.

Figure 1

Male.—Elongate, parallel, 2.9 times longer than wide; reddish brown with a darker tinge, center of pronotum and elytral suture paler, suture more broadly so apically, femora and tarsi light reddish brown, tibiae darker, antennae reddish yellow; pubescence very short, greyish, moderate in density, recumbent, hairs of pronotum a little longer and somewhat bristling.

Head densely, finely granulate, a distinct, large, rounded protuburance in center of front, vertex feebly, finely sulcate posteriorly; eyes rather large, separated by about one-third more than vertical diameter of eye as seen from front; antennae nearly 0.6 length of body, segments 3 to 10 produced laterally, ramus of third segment shorter than segment, those of segments 4 to 10 a little longer than corresponding segment, last segment three times longer than wide; last segment of maxillary palpi elongate, rather pointed, broadly rounded at inner angle, about 2.5 times longer than wide; last segment of labial palpi similar but more elongate.

Pronotum a little wider than elytra at base, densely covered with both small and moderate sized granules, larger granules uniform in density, more produced at center and inclined backwards, disk a little more prominent at middle posteriorly, median line impressed on anterior slope, side margins finely, irregularly serrate.

Elytral striae fine, feebly punctured, intervals nearly flat, surface finely, rather densely granulate, lateral two striae more distinctly impressed and with larger punctures.

Tarsi slender, a little shorter than or much shorter than tibiae, those of last pair of legs longest.

Length: 4.0 mm; width: 1.4 mm.

Described from a single specimen (male, holotype) from the Charles Dury collection, in the Cincinnati Museum of Natural History, it is labeled "Ky. near Cinc. O." There is no date or collector given.

This species can be separated from *E. hornii* Lec., the other member of the genus, by color, protuburance of front of head, and antennal characters of male. *E. hornii* Lec. is black, front just slightly protuburant, last antennal segment of male is over six times longer than wide, and rami of segments 4 to 8 are obviously longer than corresponding segments. This species is reddish brown with a darker tinge, front is distinctly protuburant or gibbous (the character from which the specific name is derived), last antennal segment of male is three times longer than wide, and rami of segments 4 to 8 are not longer than corresponding segments.

Fall (1905) refered to this specimen but was doubtful of its status. Apparently he did not notice the obvious antennal differences between it and *E. hornii* Lec. The drawing in his paper which is labeled as the antennae of the male of *E. hornii* Lec. was probably made from this specimen, for the antennae of his male type do not agree with the drawing, but are as described in the previous paragraph. I am indebted to Ralph Dury for loan of material, and to Dr. P. J. Darlington Jr. for comparison of the type of *E. hornii* Lec.

Euvrilletta brevis n. sp.

Figure 2

Elongate, parallel, about 2.4 times longer than wide; dark reddish brown to light reddish brown, base of elytra darker, suture lighter than remainder, appendages reddish yellow; pubescence yellowish, fine, very short, moderate in density, recumbent.

Head finely, very densely punctured, punctures varying somewhat in size, vertex feebly, smoothly carinate; eyes moderate in size, separated by a little less than 1.5 times their vertical diameter; antennae 11 segmented, serrate, nearly half as long as body, segments 3 to 8 rather similar in size and shape, triangular, becoming a little broader, eighth as broad as long, last three segments elongate, as long as six preceding united, ninth and tenth elongate, triangular, about as broad as eighth, ninth segment a little shorter than two preceding united, eleventh segment elongate, three times longer than wide, narrower than preceding segments, tip narrowly rounded; last segment of maxillary palpi elongate, nearly two times longer than wide, inner angle widely, evenly rounded, tip pointed, last segment of labial palpi very similar but broader, about 1.5 times longer than wide.

Pronotum transverse, 1.75 times wider than long, nearly evenly convex, pubescence changing in direction, surface very finely, evenly, not densely granulate, very small, dense punctures just visible, a short, feeble, longitudinal carina at base, center somewhat flattened.

Elytra finely, not deeply striate, striae finer apically, intervals nearly flat, surface very finely, transversely rugose.

Front coxae contiguous; middle coxae distinctly, not widely separated, mesosternal process raised, truncate, terminating between coxae; metasternum finely, densely punctured, punctures varying in size; abdomen very finely, densely punctured; first segment of middle and hind tarsi as long as three following.

Length: 4.0 to 4.2 mm; width: 1.7 mm.

Described from three specimens collected in Adams Co., Ohio, June, 1941, by C. R. Neiswander. One holotype and two paratypes deposited in The Ohio State University collection. It is probable that all are males.

This species can be separated from the other two members of the genus by relative length of ninth antennal segment and size of eyes. The ninth antennal segment of *E. xyletinoides* Fall is nearly as long as four preceding united, that of *E. texana* Van Dyke is as long as 2 to 3 preceding united, in this species it is shorter than two preceding united. The eyes of *E. xyletinoides* Fall are small, separated by a little less than two times their vertical diameter and those of *E. texana* Van Dyke are large, separated by slightly more than their vertical diameter. The eyes of this species are moderate in size, separated by a little less than 1.5 times their vertical diameter.

It is not in complete agreement with the generic characters of *Euvrilletta* given by Fall (1905). It agrees in that antennal funicle is rather feebly serrate, its outer segments are about as long as wide, and elytra are feebly striate. However, it differs in the following respects; last three segments of antennae are elongate-triangular, not elongate and nearly parallel, last segment of maxillary palpus is elongate, inner angle widely, evenly rounded, not triangular with inner angle narrowly rounded, and middle coxae are distinctly separated, not subcontiguous.

Catorama rotundum n. sp.

Figure 3

Robust, 1.6 times longer than wide; body greatly, evenly convex in profile; elytra black, shining, pronotum dark reddish brown, shining, lightest at center, head reddish brown, under surface reddish black, abdominal sutures darker, legs reddish brown, tarsi and antennae reddish yellow; pubescence fine, short, moderate in density, rather sparse on elytra.

Head very finely, densely, evenly punctured, larger punctures lacking; eyes small, separated by three times vertical diameter; fourth segment of antennae somewhat produced internally, eighth segment triangular, 1.3 times longer than wide, outer angle broadly rounded; last segment of maxillary palpi elongate, triangular, a little over two times longer than wide.

Pronotum finely, densely punctured, punctures rather finer and sparser at center, larger punctures lacking.

Elytral punctation dual, smaller punctures becoming smaller, sparser apically, nearly absent at apex, larger punctures rather small at base, moderate in size and rather sparse over rest of elytra, continuing to apex.

Front tibiae bisulcate; middle tibiae grooved; metasternal punctures dual, larger punctures moderately numerous at center, becoming much sparser laterally, reaching sides.

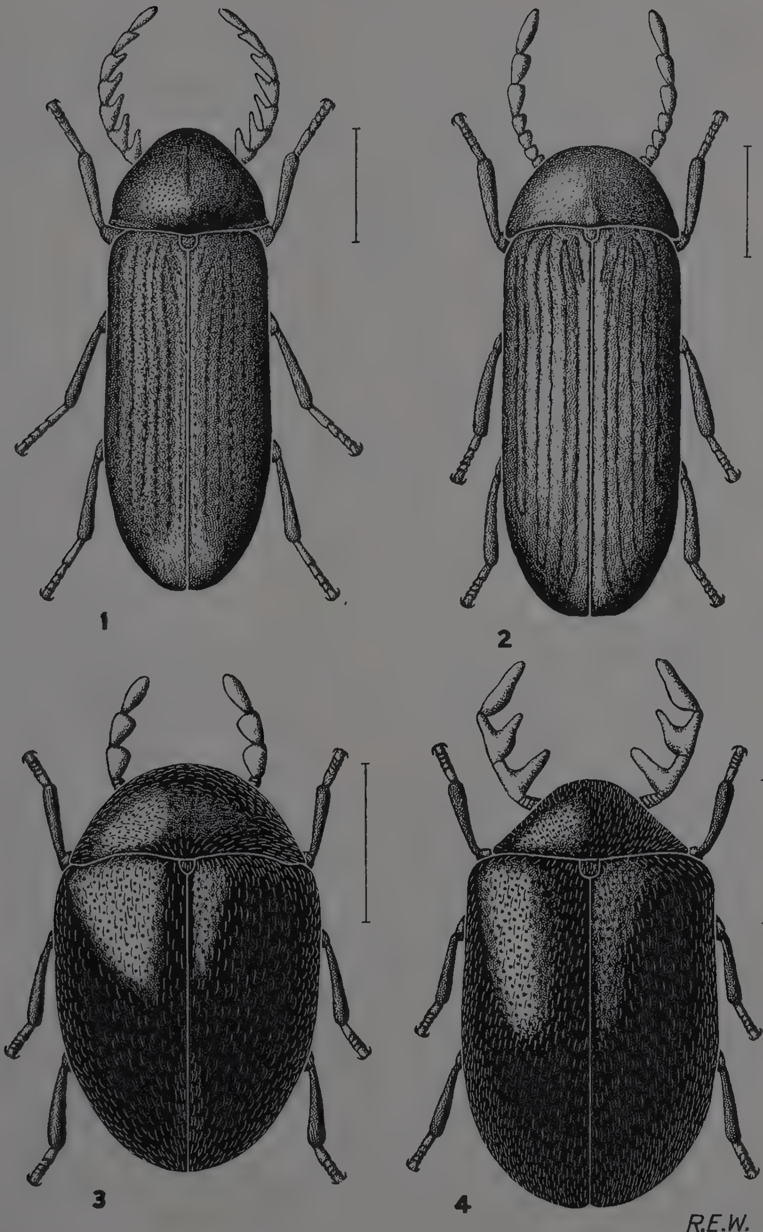

FIGURE 1. *Euceratocerus gibbifrons* n. sp., ♂.
FIGURE 2. *Euvrilletta brevis* n. sp.
FIGURE 3. *Catorama rotundum* n. sp.
FIGURE 4. *Dorcatoma foveatum* n. sp.,

(Line represents 1 mm.)

Length: 2.7 mm; width 1.7 mm.

Described from one specimen (holotype) collected in Fairfield Co., Ohio, August 15, D. J. and J. N. Knull. Deposited in The Ohio State University collection

It is closest to *C. nigritulum* (Lec.) and can be separated by a number of characters. Eyes of *C. nigritulum* (Lec.) are large, separated by a little over two times their vertical diameter as seen from front. Body is moderately convex in profile, and length is 1.7 to 2.4 mm. Eyes of this species are small, separated by three times their vertical diameter. Body is highly convex in profile (hence the specific name) and length of one known specimen is 2.7 mm.

Dorcatoma foveatum n. sp.
Figure 4

Oval, moderately elongate, about 1.6 to 1.8 times longer than wide; black, moderately shining, legs more or less reddish, tarsi and antennae, except basal segment, reddish yellow; pubescence short, somewhat sparse, recumbent, greyish.

Head very finely, densely punctured, punctures separated by own diameters or less, except at center of front where they are sparser; eyes of male separated by about 1.5 times their vertical diameter, those of female separated by about 1.66 times their vertical diameter; antennae of male with eighth and ninth segments branched, ramus of eighth segment nearly straight, a little longer than segment itself, ramus of ninth segment sinuate, not or but slightly longer than segment itself, tenth segment broadest near base, inner angle slightly curved inwardly, tip broadly rounded; last segment of maxillary palpi elongate-triangular, less than two times longer than wide, outer edge oblique; last segment of labial palpi broadly triangular, as wide as long, outer edge sinuate.

Pronotal punctures much as those of head but slightly larger.

Elytral punctures confused, distinctly larger and sparser than those of head and pronotum, separated by from one to two times own diameters, two nearly complete striae at sides, a shorter basal, third stria present.

Metasternum very deeply, broadly foveate anteriorly at center, finely, longitudinally sulcate posteriorly, a short, shallow, oblique impression usually present each side of sulcus immediately behind fovea, surface finely punctured at middle and posteriorly, much larger and denser punctures in front at each side; abdominal punctures fine, rather dense, becoming finer, usually sparser posteriorly, fifth abdominal segment of female flat or concave, that of male convex posteriorly.

Length: 2.6 to 3.2 mm; width 1.4 to 2.0 mm.

Described from 18 specimens, (eight males, ten females). Holotype (male), allotype, and 14 paratypes reared from fungi by W. E. and C. A. Triplehorn at Slaterville, New York, April 30, 1956. Holotype, allotype and ten paratypes in The Ohio State University collection, four paratypes in authors collection. Two additional paratypes in W. C. Stehr collection at Ohio University. One is labeled Athens, Ohio, May 11, 1934, W. C. Stehr, and the other Columbia Cross Roads, Pa., July 21, 1932, R. M. Leonard, both specimens are females. My thanks to Dr. C. A. Triplehorn for contribution of specimens and W. C. Stehr for loan of material.

It is very similar in most respects to *D. dresdensis* Herbst, but can be separated from it by form of metasternum. Metasternum of *D. dresdensis* Herbst is deeply sulcate throughout most of its length, however, in this species it is deeply, broadly foveate anteriorly (hence the specific name). Also the ramus of ninth antennal segment of male of *D. dresdensis* Herbst is S shaped, and longer than segment itself. Ramus of ninth antennal segment of male of this species is sinuate, not S shaped, and not or but slightly longer than segment itself.

I am indebted to J. N. Knull for many helpful hints during preparation of this paper and to Dr. D. J. Borror for taxonomic assistance.

REFERENCE

Fall, H. C. 1905. Revision of the Ptinidae of Boreal America. Trans. Am. Entomol. Soc. 31: 97-296.

ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE
1960

Organized 1891 — Incorporated 1892

Affiliated with the American Association for the Advancement of Science

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REPORT OF THE SIXTY-NINTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The 69th annual meeting was held on the campus of Antioch College April 21, 22, and 23, 1960, the first ever to be held there. More than 700 persons registered for the meetings of the senior division, about the same number as in 1959. The local committee on arrangements, under the chairmanship of Dr. John Lounsbury, did an outstanding job in providing the facilities necessary to make this meeting a real success.

The Executive Committee, the Council, and the Committee on Election of Fellows met on April 21; their reports are to be found elsewhere in this Annual Report. On Friday, April 22, ten sections and one sub-section held meetings in the following fields: Zoology, Plant Sciences, Genetics, Geology, Medical Sciences, Physics and Astronomy, Geography, Chemistry, Science Education, Anthropology and Sociology, and Conservation. More than 150 research papers were presented and discussed. Highlights of the sectional meetings included a symposium on Federally Supported Laboratories in Ohio Engaged in Research in the Physical Sciences, demonstrations of experimental studies in psycho-physiology, growth, and development at Fels Research Institute, a symposium on Industry-Related Laboratories in Physics, a panel on The Status of Geography in Our Secondary Schools, a symposium on Urban Expansion and Natural Area Preservation, and two field trips, one sponsored by the Section of Geology, the other by the Section of Conservation.

Throughout Friday the Junior Division sponsored the Twelfth Annual State Science Day in which 600 projects were entered by nearly 700 students from 240 schools. The number of

projects had to be limited, because of space, to about the number entered in 1959; the number of schools represented increased by 27. Sectional meetings were, as usual, suspended at 11:00 a.m. to give all members an opportunity to view exhibits of the Junior Division.

The annual banquet and business meeting were held Friday evening in the Dining Hall of the Antioch Union. Dean W. Boyd Alexander served as toastmaster. Greetings from Antioch College were given by President James Dixon and the response was made by the Academy's most recent past-president, Dr. Richard P. Goldthwait. Dr. Dwight M. DeLong, President of The Ohio Academy of Science, delivered his presidential address, "Man in a World of Insects." Professor G. G. Acker, Executive Secretary of the Junior Division, announced awards to outstanding high school teachers; these are identified in the report of the Junior Division, to be found elsewhere in this Annual Report. Professor Acker presented a Distinguished Service citation to Dr. Frederick H. Krecker, recognizing his outstanding service to the Junior Division. Ten-year membership awards were presented by President DeLong to Battelle Memorial Institute and to Kent State University. In the annual business meeting the membership formally approved a constitutional amendment setting up the office of President-Elect, and elected officers, as listed at the head of this annual report, to serve for the coming year. The membership also approved the formation of a new section of the Academy, Section K, Genetics.

Sixteen members of the Academy were announced as newly elected Fellows. Their names and sectional affiliations follow:

J—Robert W. Alrutz	J—Floyd E. Heft
J—Daniel C. Armbruster	G—Robert K. Ingham
J—Francis J. Baker	J—Robert H. Mills
I—Joseph K. Balogh	E—Charles A. Randall, Jr.
J—Samuel W. Bone	F—James A. Rinier
I—Dwight G. Dean	J—H. Granville Smith
A—Lester O. Gilmore	E—Paul B. Taylor
J—Scott C. Hartman	G—S. J. Vellenga

Respectfully submitted,

George W. Burns, *Secretary*

REPORT OF THE EXECUTIVE COMMITTEE AND THE COUNCIL

The Executive Committee met June 13, September 5, October 17, December 11, 1959, January 23, February 20, March 12, and April 21, 1960, for a total of more than 33 hours; the Council met December 12, 1959 and April 21, 1960.

1. *Meetings of the Executive Committee.*—In addition to much routine business incident to the operation of the Academy, the Executive Committee: approved locating its central offices at Battelle Memorial Institute, defined the duties of its new Executive Secretary, approved changes in requirements and privileges of corporation membership, approved text and format for the new brochure, authorized a membership-officer directory card for all members effective with the summer of 1960, set up a temporary finance sub-committee to plan the Academy's investment program, accepted the invitation of Western Reserve University to host the Academy's 1964 meeting, approved a budget for 1960, recommended to Council a constitutional amendment setting up the office of President-Elect, approved four proposals to be presented to the National Science Foundation (Visiting Scientists for Ohio Schools, Traveling Science Library, Visiting Scientists for 69th Annual Meeting, Development and Operation of Science Days in Ohio), worked out long range policy proposals for presentation to the membership, recommended to Council the formation of Section K (Genetics) from subsection AB, and approved a new Junior Division center at Ashland College, and authorized awards to Dr. Krecker and to ten-year institution members.

2. *Meetings of the Council.*—Reports were presented by all officers and committee chairmen. Their annual reports are presented in the following pages.

Council approved two resolutions from Section J regarding preservation of natural recreational and educational areas. Reports of this action were subsequently sent to President Dixon of Antioch College in support of efforts to maintain Glen Helen against disturbance. In other actions, Council approved the proposed constitutional amendment on a President-Elect for presentation to the membership at the annual meeting, and approved formation of Section K, Genetics.

Dates for the 1961 Annual Meeting at the University of Cincinnati were announced for April 20, 21 and 22, 1961.

Respectfully submitted,

George W. Burns, *Secretary*

REPORT OF THE TREASURER

Fiscal Year 1959

Herewith is submitted a financial statement of The Ohio Academy of Science as of December 31, 1959. The statement is a true copy of the financial statement certified by our auditor, Mr. P. H. Sturtevant, 547 E. Broad St., Columbus, Ohio. A copy of the auditors report is on file at the Academy's central office.

Respectfully submitted,

Robert M. Giesy, *Treasurer*

EXHIBIT A. Comparative Balance Sheet as of December 31, 1959 and 1958

ASSETS

	1959	*1958*	*Increase (Decrease)*
Current Expense Fund:			
Cash in the Huntington National Bank	$ 887.97	$18,084.97	$(17,197.00)
Investments:			
Buckeye Federal Savings & Loan Association	5,000.00		5,000.00
Franklin Federal Savings & Loan Association	5,000.00		5,000.00
Ohio Federal Savings & Loan Association	5,000.00		5,000.00
Park Federal Savings & Loan Association	1,000.00		1,000.00
U. S. Savings Bonds—Series G		1,900.00	(1,900.00)
Modern Finance Company	8,000.00	8,000.00	—0—
Total Current Expense Fund Assets	$24,887.97	$27,984.97	$ (3,097.00)
Research Fund			
Cash in the Huntington National Bank	$ 213.08	$ 200.08	$ 13.00
U. S. Savings Bonds—Series G	200.00	200.00	—0—
BancOhio Stock, 34 shares	541.44	497.34	44.10
First Federal Savings & Loan Association	1,478.93	1,428.49	50.44
Totol Research Fund Assets	$ 2,433.45	$ 2,325.91	$ 107.54
Total Assets	$27,321.42	$30,310.88	$ (2,989.46)

LIABILITIES AND NET WORTH

	1959	*1958*	*Increase (Decrease)*
Liabilities:			
Current Expense Fund:			
Dues paid in advance	$ 45.00	$ 48.00	$ (3.00)
Research Fund	—0—	—0—	0
Total liabilities	$ 45.00	$ 48.00	$ (3.00)
Net Worth:			
Current Expense Fund	$24,842.97	$27,936.97	$ (3,094.00)
Research Fund	2,433.45	2,325.91	107.54
Total Net Worth	$27,276.42	$30,262.88	$ (2,986.46)
Total Liabilities and Net Worth	$27,321.42	$30,310.88	$ (2,989.46)

EXHIBIT B. Statement of Revenues and Expenses for the year ended December 31, 1959

Current Expense Fund		
Revenues:		
Membership dues—1959 and prior years		$ 4,423.50
Gifts:		
C. M. Goethe	$ 100.00	
Pittsburgh Plate Glass Co.	100.00	200.00
Interest:		
U. S. Savings Bonds—Series G	$ 23.75	
Modern Finance Co	400.00	
Savings accounts	320.83	744.58

Junior Academy			1,771 82
National Science Foundation:			
Grant No. 2714		$1,200.00	
Grant No. 8099		750.00	
Grant No. 9232		7,000 00	8,950.00
Other income:			
Special paper sale		$ 1.55	
Rental of exhibit space		25.00	26 55
TOTAL REVENUES			$16,116.45
EXPENSES:			
Subscriptions and engravings—Ohio Journal of Science:			
½ cost of engraving volumn 58	$ 227.99		
Subscriptions	2,150.00	$2,377.99	
Office supplies and expenses		864.19	
Secretary expense (including cost of obtaining executive secretary)		2,239.79	
Treasurer expense		345.23	
Executive secretary and clerical salaries		5,866.35	
Payroll taxes		146 67	
Printing annual report		191.16	
Printing announcements and notices		302.25	
Auditing		65 00	
Public relations, certificates and awards		534.11	
AAAS Academy Conference		23 66	
Junior Academy		2,820 43	
National Science Foundation Grant No. 2714		2,269.84	
National Science Foundation Grant No. 5127		73.96	
National Science Foundation Grant No. 8099		639.82	
National Science Foundation Grant No. 9232		450.00	
TOTAL EXPENSES			19,210.45
EXCESS EXPENSES OVER REVENUES FOR THE YEAR ENDED DECEMBER 31, 1959			$(3,094.00)
RESEARCH FUND:			
REVENUES:			
Interest on Savings account			$ 50.44
Interest on U. S. Savings bonds			2.50
Dividend on BancOhio stock			54.60
American Association for Advancement of Science Grant			275.00
TOTAL REVENUES			$ 382.54
EXPENSES:			
Geology Research Field Work and Air Photos			275.00
EXCESS REVENUES OVER EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1959			$ 107 54

EXHIBIT C. CASH RECONCILIATION for the year ended December 31, 1959

CURRENT EXPENSE FUND:			
CASH BALANCE January 1, 1959			$18,084.97
Income per Exhibit B		$16,116.45	
1959 and later years collected in 1959		45.00	
Total		$16,161.45	
Less: 1959 dues collected in 1958		48.00	
		$16,113.45	
Investments cashed in during year:			
Savings account at Park Federal Savings & Loan Association	$4,000.00		
U. S. Savings Bonds—Series G	1,900.00	5,900.00	
Total cash receipts			22,013.45
			$40,098.42

Less: Expenses per Exhibit B		$19,210.45	
Cash invested in Savings Accounts:			
Buckeye Federal Savings & Loan	$5,000.00		
Franklin Federal Savings & Loan	5,000.00		
Ohio Federal Savings & Loan	5,000.00		
Park Federal Savings & Loan	5,000.00	20,000.00	
Total cash expenditures			39,210.45
CASH BALANCE December 31, 1959			$ 887.97
RESEARCH FUND:			
CASH BALANCE January 1, 1959			$ 200.08
Income per Exhibit B			382.54
			$ 582.62
Less: Expenses per Exhibit B		$ 275.00	
Investment in BancOhio Stock		44.10	
Interest credited to savings account		50.44	369.54
CASH BALANCE December 31, 1959			$ 213.08

ROBERT M. GIESY, *Treasurer*

REPORT OF THE ACADEMY LIBRARIAN

The Ohio Journal of Science, official publication of The Ohio Academy of Science was used to initiate 19 new exhanges, with the Ohio State University Libraries receiving 31 new titles in exchange. Of this number 17 new exchanges are with foreign institutions, 2 with domestic. This represents a net decrease of 8 as the total for 1958/59 was 556. The total number of exchanges as of April 1, 1960 is 548, 419 of which are foreign and 129 domestic.

There were 27 institutions dropped from the exchange list, 20 of which were foreign institutions, 7 domestic. The exchange list was checked and correspondence brought up-to-date our exchange program by dropping the institutions whose publications were no longer being received or whose publications had been put on a subscription basis.

Revenue from the sales of the *Special Papers*, by the Gift and Exchange Division was $5.15.

Respectfully submitted,

JEAN BROTSMAN, *Librarian*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of *The Ohio Journal of Science* was held at Columbus on April 2, 1960. The meeting was called to order by Board Chairman, Bates. Present were, Dr. B. S. Meyer and Dr. R. L. Bates, representing The Ohio State University; Dr. W. G. Gambill, representing The Ohio Academy of Science; as well as Dr. H. L. Plaine and Dr. R. A. Popham of The Ohio Journal of Science staff. Dr. Warren P. Spencer was unable to attend.

Minutes of the last meeting were approved as read.

Dr. W. G. Gambill was elected Chairman of the Board for the year 1960–61.

The report of the Business Manager was approved as read. This report, which accompanies these minutes, is mainly in the form of a financial statement for Volume 59. Dr. Popham reported that (1) the bank balance is about $400.00 less than at the same time a year ago, (2) circulation of the Journal has increased to 2,030 during the year, (3) the total average cost per page for publishing the Journal in 1959 was $17.58, (4) an increase of $500 in the annual contribution of The Ohio State University has been procured and it is expected that contributions by The Ohio Academy of Science, due to an increase in membership, will increase by a like amount during the current year, (5) there is considerable likelihood that income from advertising carried in the Journal will increase by $200 or more over that for Volume 59.

The report of the Editor, Dr. Plaine, was approved as read. A copy of this report is attached to these minutes. The Editor indicated that the Journal is about six months behind in publication of papers. This delay in publication of papers is considered to be about minimum. In a discussion following the Editor's report the Board unamiously approved a motion stating that all books for review in The Ohio Journal of Science must be approved by the Editor-in-chief before submission to reviewers. The maximum length of book reviews is to be 250 words. It is expected that these tighter controls will bring the supply into closer balance with the space available for the publication of book reviews.

The following staff members were re-elected for the year 1960–61: Dr. Plaine, Editor;

Dr. Popham, Business Manager. After his appointment Dr. Plaine announced the re-appointment of Dr. T. H. Langlois as Book Review Editor. Both Dr. Bates and Dr. Meyer reported that they had tried repeatedly to obtain favorable action by the administration of The Ohio State University concerning their suggestion that University representatives be appointed for three-year terms and that a replacement be designated immediately to take Dr. Meyer's place on the Board.

The Board authorized the Business Manager and the Editor to seek a part-time paid technical editor.

There being no further business, the Board adjourned.

Respectfully submitted,
RICHARD A. POPHAM, *Secretary of the Board*

THE OHIO JOURNAL OF SCIENCE
VOLUME 59—FISCAL YEAR 1959
BALANCE SHEET

	Vol. 58 Fiscal Year 1/1/58 12/31/58	Vol. 59 Fiscal Year 1/1/59 12/31/59
RECEIPTS:		
Bank balance at beginning of period	$ 2,974.19	$ 3,230.08
O.S.U.—paid for subscriptions	2,500.00	2,750.00
O.A.S.—paid for subscriptions	2,044.50	2,150.00
Non-members—paid for subscriptions	599.00	739.00
Separate numbers, volumes and reprints sold	656.99	430.36
50 year index sold	20.00	15.00
O.A.S.—paid ½ cost of plates	332.40	227.99
O.A.S.—paid for annual report	148.83	191.16
Miscellaneous	132.55	1,062.60*
Advertisements	383.94	406.38
Charles F. Kettering—Gift	0.00	0.00
	$ 9,792.40	$11,202.57
EXPENDITURES:		
Spahr and Glenn—printing O.J.S.	$ 5,628.44	$ 5,824.57
Bucher Engraving—plates	455.99	858.70
Postage and express	239.91	248.34
Labor	53.00	283.50
Office expenses and bank charges	84.00	26.77
Advertising of the O.J.S.	50.00	0.00
Reprints	26.93	53.37
Mailing envelopes	0.00	0.00
Refunds	10.50	0.00
Miscellaneous	13.55	1,221.12**
Bank balance at end of period	3,230.08	2,686.20
	$ 9,792.40	$11,202.57

* **A $1,000.00 loan was made to the Ohio Academy of Science on 9/14/59 and was repaid on 10/22/59.

**A complete set of the journal (1900–1958 inc.) was bound at a cost of $162.00.

**Art work, etchings, metal base and proofs of new cover design cost $41.15.

**A zinc etching was made for an advertiser. The cost of $17.97 will be recovered by billing the advertiser.

THE OHIO JOURNAL OF SCIENCE
REPORT OF THE EDITOR OF VOLUME 59, 1959, to the Joint Administrative Board

Volume 59 of The Ohio Journal of Science contained 408 pages, of which 353 pages were devoted to 51 scientific papers in 8 areas of science (as designated by sections of The Ohio Academy of Science); 18 pages were devoted to affairs of the Academy; 11 pages to advertising; and 26 pages to announcements, book notices, the index and table of contents, and routine journal format. Fifteen book notices were published, which represents a considerable reduction from the number reviewed in previous volumes. This was not due to any decrease in the number of reviews submitted to the editor, but was the result of conserving space in order to publish more papers and accommodate special copy.

Although editorial policy has been not to divulge the names of reviewers, I wish to thank our many colleagues, some of whom are not members of the Academy, for their service as referees and reviewers.

Respectfully submitted,

Henry L. Plaine, *Editor-in-Chief*

Distribution by Field of Articles Published in 1959

Field	No. of articles	Total pages	Percent
Anthropology and Sociology	3	27	4.8
Chemistry	9	65	18.4
Conservation	2	9	2.5
Geology	9	86	24.4
Physics and Astronomy	1	6	1.7
Plant Sciences	7	64	18.1
Zoology	18	85	24.1
Genetics	2	21	6.0
Total Scientific Papers	51	353	100.0
Other			
Notices			
Academy	7	4	
Book	15	4	
Annual Report of Ohio Academy of Science		14	
Table of Contents		4	
Index		2	
Advertising		11	
Journal Format		16	
Number of pages for other:		55	
Total number of pages in Volume 59:		408	

REPORT OF THE DIRECTOR OF PUBLIC RELATIONS

The position of the Director of Public Relations has become, in part, an advisory one. Except for such items as the awarding of NSF or research grants to or through the Academy, the individual contacts by the Executive Secretary or through his office constitute the public relations of the Academy during the year. Thus, he certainly has to be the one responsible for any news releases related to these items. However, the Director of Public Relations can be useful as an advisor to the Executive Secretary, can provide Executive Committee authority to act in many cases (e.g., when the Committee is unavailable between meetings or in the many cases which do not require action of the entire Committee), and can provide the Executive Committee with a means of keeping informed on the activities of the Executive Secretary in this area of service.

However, the Director of Public Relations must assume full responsibility for the publicity directly associated with the annual meeting, both in the matter of news releases and in making the local contacts and arrangements, for the Executive Secretary could not be expected to add this concentrated task to his unusually heavy other duties at this time of year. The amount of actual paper work for the Director has been reduced by having the typing, mimeographing, and mailing done largely in the central office. Extra clerical help will probably be required for this purpose in the central office in the future, and it is recommended that the bugdet of the Executive Secretary be expanded to cover this item. It is also recommended that sufficient extra copies of the program of the annual meeting be printed to permit mailing to the various news outlets, thus saving much correspondence and details on many news releases.

We have had better luck this year than previously in securing titles and abstracts from the section Executive Vice-Presidents. One particular item which should be mentioned is the lack of abstracts or information of any sort for the symposia. As a result we have been unable to supply this information to news services requesting it. These symposia are the chief items of news interest in the program and we must have something to offer the news services. Another suggestion is that these types of programs be alternated timewise as much as possible so that reporters can get to more than one such program (not to mention Academy members).

Respectfully submitted,

John R. Coash, *Director*

REPORT OF THE EXECUTIVE SECRETARY OF THE JUNIOR DIVISION, OHIO ACADEMY OF SCIENCE

The activities of the Junior Division during its twelfth year were centered around the Science Day Program. Increased interest in all sections of the state forced District Planning Committees to adopt new, and in some cases novel, methods for selecting projects to participate at State Science Day. Limitation of the number of projects at State Science Day was necessary because of limited facilities at Antioch College and the time and personnel available for judging. Special emphasis was placed upon the extension program involving the affiliation of local science days with the Junior Division for the purpose of selecting participants at District Science Days from the outstanding projects at local level. One new district became operational and a second was approved to function next year. This will bring to ten the total number of districts holding science days in 1961. Additional changes are anticipated in order to keep pace with increased interest and activity in the public schools. The School Awards Program was changed with respect to name, stipend, and method of administration of the awards. Favorable response on a proposal for funds to help defray expenses of Junior Division Program for 1960–61 has been received from National Science Foundation. Other activities of the Junior Division prescribed by the constitution (Ohio Academy of Science News, Teacher Awards, State Science Day Award, and Scholarship Tests) were conducted in the normal manner with broader coverage than in previous years.

Section I Organization

A. *North District:* Defiance College, Defiance became the center for a new district involving Defiance, Henry, Paulding, Van Wert, and Williams Counties. 195 students from fifteen schools participated in the first District Science Day on April 2, 1960. Included in the awards ceremony were two internationally respected personalities, Dr. Kevin McCann, President of Defiance College and speech writer for President Eisenhower welcomed the participants to the campus; and Dr. Paul Siple, Antarctic Explorer, delivered an address and presented certificates to the superior projects.

B. *New District:* Administrative details have been completed for the establishment of our tenth district to be centered at Ashland College. An organizational meeting will be held early in May to elect officers and to plan for 1961. This new district includes Lorain, Ashland and Richland Counties from North Central District; Medina, Holmes and Wayne counties from Northeast District; and Knox county from Central District.

C. *West District:* A new center must be located to replace Wittenberg University which has requested relief from district responsibilities.

D. *Judging Committee:* A permanent committee to take charge of details and recommendations concerned with judging was formed within the framework of the council of the Junior Division. R. E. McKay, former Executive Secretary of the Junior Division, was appointed as the chairman of this committee.

Section II Local Affiliated Science Days

Eighty-one school organizations, representing more than 200 schools, have affiliated their local science days with the Junior Division. Reports received to date indicate that more than 12,500 presented projects at these Local Science Days which were visited by nearly 82,000 persons. All grades from Kindergarten through 12th were represented. The following table indicates growth of the extension program:

District	No. 1958	No. 1959	No. 1960	Participation 1960
Southeast		2	9	1300
East	1	2	2	No reports
Northeast		2	2	271
North Central	2	14	43	6828
Central	2	11	11	626
Southwest		2	2	310
West	1	3	4	591
Northwest	4	7	5	735
North			3	1841
Total	10	42	81	12502

Section III District Science Days

The number of students participating at District Science Days was about the same as 1959 (more than 6000) in spite of measures taken by some districts to reduce the number of entries. 11,000 persons visited the nine District Science Days to view projects from more than 525 schools.

Central District limited the number of entries permitted from a school to a maximum of 5% of that school's science population. Joint projects were not permitted to enter. A point system of judging was used to select entries for State Science Day.

North Central District restricted entries at District Science Day to single projects that had received a superior rating at an affiliated local science day. Six county and 37 local school systems have affiliated their science days with the Junior Division. With all but six reporting a total of 6828 students participated and 46,000 persons visited local science days in this district. Selection of entries for State Science Day was accomplished by using a point system of evaluation.

Northwest District did not permit joint projects and restricted participation to grades 8 through 12. Further reduction in number of entries was accomplished by limiting the number of entries from the 8th and 9th grades to 5% of the number of science students in these grades. Projects were judged in the conventional manner, but the superiors were re-judged using a point system to determine the State Science Day entries.

The following table gives a summary of the 1960 District Science Day Program:

		No. of Projects	No. of Students
March 19,	East, Muskingum College	326	375
April 2,	North, Defiance College	172	195
	Northwest, Bowling Green	789	789
	Northeast, Kent	777	807
	West, Wittenberg University	519	606
April 9,	Southeast, Ohio University	402	447
	North Central, Heidelberg	1047	1047
	Central, Columbus	1000*	1000*
	Southwest, Miami	1000*	1000*
Total		6038	6266

*Estimate.

Section IV State Science Day

The number of projects at State Science Day was limited to 600 by permitting each district to send 14.3% of the number of projects from 9th through 12th grades at their 1959 District Science Day. The limitation in number of projects was based upon the facilities at Antioch College and the number of persons available for judging. The total number of students participating will be between 650 and 700 since six districts permit joint projects. Sectional meetings will be suspended at 11:00 A.M. for judging of science day projects. 240 schools will be represented by projects at Antioch College. Districts were allowed spaces as follows: Southeast 42; East 33; Northeast 93; North Central 107; Central 87; Southwest 61; West 51; Northwest 112; and North 27.

Section V Ohio Academy of Science News

Volume XII of the Ohio Academy of Science News contained a total of 20 pages devoted entirely to articles of interest to Academy members and science teachers. Mrs. Clara Kenney of Chillicothe served as editor for this volume and has agreed to continue in that capacity for another year. Circulation increased to 10,000 copies as a result of an effort by the central office. All three issues were mailed from the central office.

Section VI Scholarship Tests

Scholarship tests will be administered by the testing service of Antioch College. Mr. William R. Zeitler of Parma High School is chairman of the scholarship committee.

Section VII Teacher Awards

The 1960 Outstanding Teacher Award winners are:

Southeast —Chester Hurd, Chillicothe High School
East —
Northeast —Jack Miller, Shaker Heights High School
North Central—Kenneth Bonsell, Avon Lake High School
Central —
Southwest —Miss Etta Louise Elberg, Walnut Hills High School, Cincinnati
West —Karl L. Braun, Keifer Junior High School, Springfield
Northwest —Mrs. Norman (Dorothy) Fish, Pandora-Gilboa High School
North —Marion Fisher, Holgate High School

SECTION VIII SCHOOL AWARDS

The Kroger Company presented six awards this year. Mr. Irwin Slesnick, Chairman of the Special Awards Committee, announces the following winners:

Southeast —Jackson High School
Northeast —Benedictine High School, Cleveland
North Central—Clyde High School
Central —West High School, Columbus
Southwest —Mother of Mercy High School, Cincinnati
West —Urbana High School

SECTION IX STATE SCIENCE DAY AWARD

Pandora-Gilboa High School. Pandora was the only State Science Day award winner for 1959. Nine projects were entered and eight were rated Superior. Thirty-six schools are competing for the award this year.

SECTION X CHANGES IN REGULATIONS

Regulations changing the name of the Kroger Award to the Frederick H. Krecker Award were adopted by the Junior Division Council and approved by the Executive Committee.

SECTION XI PERSONNEL

Changes in personnel of the Junior Division have been made as follows:
Councilmen:
Southeast —Robert Harrison, Jackson High School
East —John Bisbocci, Martin's Ferry High School
Northeast —Lewis Sturm, Shaker Heights High School
North Central—H. Ray Wagner, Monroe County Schools
Central —Donald Murphy, Eastmoor High School, Columbus
Southwest —Paul Ruark, Lemon-Monroe High School
West —Karl Braun, Keifer Junior High School, Springfield
Northwest —George Clark, Archbold High School
North —Richard Hollstein, Montpelier High School

Chairmen:
State Science Day Award Committee—George Clark, Archbold High School
Scholarship Committee—William R. Zeitler, Parma High School
Judging Committee—Robert E. McKay, Bowling Green State University.

SECTION XII MISCELLANEOUS

Owens-Illinois Glass Company donated 700 sets of souvenir glasses for distribution to state science day participants.

Executive Secretary, Junior Division served as a member of the Toledo Science Day Advisory Committee. 1100 projects were displayed at this event.

Executive Secretary has been appointed to the committee on Junior Academies of the Academy Conference, A.A.A.S.

Dr. Arthur Lutz, Councilman from West District and Rudolph Gerlach, Councilman from East District, have been awarded NSF fellowships for next year.

Junior Division has been invited to display conservation projects at the Paul Bunyan Forestry Exposition, New Lexington on September 21–23.

500 copies of a 10 page pamphlet on heart projects were reproduced and distributed.

It is anticipated that a grant from National Science Foundation will enable the Junior Division to publish a "Directory of Science Days" and "A Handbook for Science Days."

Respectfully submitted,
GERALD ACKER, *Executive Secretary*

REPORT OF THE TRUSTEES OF RESEARCH FUNDS
FOR THE PERIOD OF APRIL 1959 TO APRIL 1960

During this period the Trustees received the following requests for grants and all of them were honored as follows:

Dr. Robert W. Long, Department of Botany, Ohio Wesleyan University, for studies of THE COMPOSITAE OF OHIO (in Central Ohio)....$200.00
Dr. T. Richard Fisher, Department of Botany, The Ohio State University, for studies of THE COMPOSITAE OF OHIO (in Northern Ohio)....$200.00
Dr. H. R. Eggleston, Department of Biology, Marietta College for completion of studies of BIVALVE MOLLUSCA OF OHIO, OF THE FAMILY UNIONIDAE....$100.00
Prof. Janet P. Toy, Department of Biology, Wittenberg University for A STUDY OF POSSIBLE METABOLIC PATHWAYS OF CERTAIN ASCOMYCETES....$150.00
Total of four grants....$650.00

This leaves a balance of $108.00 available from the A.A.A.S.

Respectfully submitted,
WILLIAM C. BEAVER, *Chairman*

REPORT OF THE OHIO FLORA COMMITTEE

The first of a series of proposed publications, *Woody Plants of Ohio* will be published by The Ohio State University Press and is expected to appear by June, 1960.

The National Science Foundation has approved a proposed project, *The Monocots of Ohio*! The grant became effective November 1, 1959, with E. L. Braun being named the chief investigator. The taxonomic treatment of the grasses will be directed by Clara Weishaupt.

Work is continuing on other parts of the Flora. William Adams is about a year away from the manuscript phase on the *Ferns of Ohio*. Percy Lilly of Heidelberg College will begin work on the nonwoody Ranales of the Dicotyledons. William Gambill is progressing on the Legume project which will be expanded to include the Rosaceae of Ohio. Warren A. Wistendahl, also of Ohio University, will participate as coinvestigator of that project.

With the aid of a grant from The Ohio Academy of Science, the Compositae project under the coinvestigatorship of T. R. Fisher and Robert W. Long, Jr., should be about one-fourth finished. Application for a grant from the National Science Foundation should be in order by the fall of 1960.

The family Cruciferae has been undertaken by William Easterly of Bowling Green. This investigation began locally and is expected to expand and include the Cruciferae of Ohio.

Respectfully submitted,

T. RICHARD FISHER, *Chairman*

REPORT OF THE ACADEMY HISTORIAN

The series of reports to the various sections on their historical development was continued during the past year with papers read to the Section of Geology and the Section of Medical Sciences. Plans have been developed to continue reporting to two sections each year.

Herewith is assembled, for the first time, a complete roster of the editors and business managers of the *Ohio Naturalist* (Nov. 1900–1915) and of its successor, *The Ohio Journal of Science* (Nov. 1915–to date).

1. *Editors-in-Chief*
   John H. Schaffner, vol. 1, 4–7, 9–17.
   James S. Hine, vol. 2, 8.
   F. L. Landacre, vol. 3.
   Frederic H. Krecker, vol. 18–29.
   Herbert Osborn, vol. 30–32.
   Laurence H. Snyder, vol. 33–41.
   Glenn W. Blaydes, vol. 42–50.
   Earl L. Green, vol. 51–52.
   Richard H. Böhning, vol. 53–56(4).
   Henry L. Plaine, vol. 56(5)–to date.

2. *Business Managers*
   James S. Hine, vol. 4–20 (1903–1920). (Sometimes referred to as Associate Editor, but was in charge of business affairs.)
   Lewis H. Tiffany, vol. 21–29.
   Bernard S. Meyer, vol. 30–41.
   John A. Miller, vol. 42–48.
   Richard A. Popham, vol. 49–to date.

3. *Associate Editors, Book Review Editors, Associate Business Managers, etc.*
   Frederick W. Ives, vol. 16 (1915–1916). (Assoc. ed.)
   Thomas G. Phillips, vol. 17 (1916–1917). (Assoc. ed.)
   Jay B. Park, vol. 18–31. (Assoc. ed.)
   L. H. Snyder, vol. 32. (Assoc. ed.) (Became editor with vol. 33; no Assoc. ed. appointed until vol. 41.)
   John A. Miller, vol. 40–41. (Assoc. bus. Manager) (Became Bus. mgr. with vol. 42; no Assoc. bus. mgr. appointed.)
   Glenn W. Blaydes, vol. 41. (Assoc. ed.) (Became editor with vol. 42; no Assoc. ed. appointed until vol. 50.)
   Ralph H. Davidson, vol. 43–47. (Asst. bus. manager)
   Earl L. Green, vol. 50. (Assoc. ed.) (Became editor; no Assoc. ed. until vol. 52.)
   Richard H. Böhning, vol. 50–52. (Advertising repres.)
   Curtis M. Wilson, vol. 50–51. (Book rev. ed.)
   Frank W. Fisk, vol. 52–57(2). (Book rev. and Assoc. ed.)
   Thomas H. Langlois, vol. 57(3)–to date. (Book rev. ed.)

Respectfully submitted,

RALPH W. DEXTER, *Chairman*

REPORT OF THE COMMITTEE ON INSTITUTION AND CORPORATION MEMBERS

During the period covered by this report, the committee was unable to add new names to the roster of Institution and Corporation Members of the Academy.

This year the Pittsburgh Plate Glass Foundation again supported the program of the Section of Chemistry by a grant of $100.

Respectfully submitted,

P. ROTHEMUND, *Chairman*

REPORT TO THE COUNCIL OF THE SCIENCE TEACHER CERTIFICATION COMMITTEE

The Committee on Science Teacher Certification met in Columbus at the Battelle Institute on Saturday morning, October 24, 1959. All but three members were present. Professor Garrett was invited as consultant, but at the last moment was unable to attend and the State Board of Education was unable to send a representative.

The Committee recommended the following changes in the wording of our report to the Council given April 16, 1959. These changes do not affect the overall recommendations approved by the Council. Under paragraph 2 B, add the word "Astronomy" after "Physical Geography" and the word "Conservation" after "Human Geography." Under C, General Science, it was suggested that we change the last item to 3 hours minimum, Physical Geography.

After some discussion, it was voted to recommend to the Council of the Academy that the Committee make out an application to the National Science Foundation for funds for a fact-gathering investigation concerning the preparation of science teachers in the State of Ohio. Secondly, it was voted that the chiarman contact the proper person of the State Board of Education to discuss the proposed changes in the certification of science teachers.

Mr. May, who is in charge of the science certification was ill and not available for consultation and no one else was put forward to discuss the material with the chairman. Finally I made contact with Mr. May by mail and received the following reply from him. "I have received your letter of March 28th in which you included recommendations of the Ohio Academy of Sciences for certification in the various fields of science. Please be advised that I shall keep this information until such time as we consider the revision of our certification regulations."

Respectfully submitted,

J. C. GRAY, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the members of The Ohio Academy of Science express to the Administration of Antioch College, to Dr. John Lounsbury, chairman of the local committee on arrangements, and to the several members of his committee, their appreciation of the excellent facilities and thoughtful hospitality which have contributed so richly to the success of this, the 69th meeting of the Academy.

Respectfully submitted,

FRANK O. HAZARD, *Chairman*

REPORT OF THE NECROLOGY COMMITTEE

In alphabetical order there follows a listing of the deaths that occurred in the membership of The Ohio Academy of Science in the interval between April, 1959 and April, 1960.

Respectfully submitted,

A. G. MCQUATE, *Chairman*

Dr. Lawrence Major Dickerson, a member of the Academy in the Conservation Section since 1939. He was born at Cadiz, Ohio, June 26, 1899, received his B.S. degree at the College of William and Mary in 1924; the M.S. degree in 1929 and the Ph.D. degree in 1930 from the University of Virginia. Dr. Dickerson was Professor of Biology at Cumberland University, 1930–1935; he left the teaching field to become assistant Wildlife Technician, National Park Service, 1935–38, and then became Biologist, Soil Conservation Service from 1938–1959.

On August 13, 1923 he married Arline Eubank, by whom he had two sons, Laurence Willis and Charlesworth Lee, and one daughter, Mrs. George Minter.

Dr. Dickerson was a member of the following honor societies: Omicron Delta Kappa, Phi Beta Kappa, and Sigma Xi. He published a number of scientific papers and many short articles for the Nature Magazine.

Dr. Dickerson died June 15, 1959 of reticular cell sarcoma and was interred in Oak Hill, Cemetery, Fredericksburg, Virginia.

Dr. Edna Eisen was a fellow of the Geography section of the Academy. She was born in Milwaukee, Wisconsin, June 27, 1895. She received her Ph.B. degree in 1928, M.S. in 1929, and Ph.D. degree in 1948, all from the University of Chicago.

Dr. Eisen taught in the Milwaukee Public Schools from 1915 to 1935, and then was on the faculty of the Department of Geography at Kent State University from 1935-1960. She received honors with her Ph.B. degree and was a member of Sigma Xi and Delta Kappa Gamma.

Her Publications consisted of "Our Country from the Air," 1937, and numerous articles in geography periodicals.

She died April 15, 1960 of cerebral hemorrhage and was buried at Milwaukee, Wisconsin.

Dr. Harold Raymond Nelson, Fellow of the Physics Section and manager of Battelle Memorial Institute's department of Physics at the time of his death.

He was born in Brattleboro, Vermont, December 4, 1904.

He received his A.B. degree at Amherst College in 1926, and his Ph.D. in Physics at Cornell University in 1934.

Dr. Nelson was assistant in Physics at Cornell 1927–29; instructor, 1929–34; research physicist, Battelle Memorial Institute, 1934-41; assistant supervisor, 1941–43; supervisor, 1943-53; manager, Dept. of Physics, 1953 until the time of his death.

On June 26, 1932, he married Helene Graham Browne, who survives him, as do also a daughter, Alice Jean, and a son, Robert Browne.

He received many honors, including Theta Delta Chi; Gamma Alpha (National President); and Sigma Xi. He was affiliated with the American Physical Society, Acoustical Society of America, The American Nuclear Society, American Crystallographic Association. He was a member of Atomic Energy Commission's Advisory Committee on Isotope and Radiation Development; Chairman, Ohio Atomic Energy Advisory Committee. He developed the first electron diffraction camera built in America. He was one of the leading American scientists who made up the United States delegation to the first (1955) International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland.

Dr. Nelson has written extensively for technical and scientific publications. He came to an untimely death on April 3, 1960 as a result of injuries from a boating accident and was buried at St. Lucia, British West Indies.

Dr. Edward Loranus Rice, Fellow in the Zoology section, President of the Academy 1906–07, Secretary 1912–23, Professor Emeritus of the Department of Zoology, Ohio Wesleyan University.

Dr. Rice was born in Middletown, Conn., March 18, 1871. He received his A.B. degree, 1892, at Wesleyan, Conn.; Ph.D. degree in Zoology, 1895, at Munich; Sc.D., 1927, Wesleyan. He began his 50 consecutive years of teaching as Assistant Professor at Wesleyan in 1896; Professor of Biology and Geology, Allegheny 1896–98; Professor of Zoology, Ohio Wesleyan 1898-1941; War Emergency Professor Ohio Wesleyan 1942-45; Acting President, Ohio Wesleyan 1938-39; Visiting Professor at Ohio State University Lake Laboratory 1905, '06, '08, '09, '12.

Dr. Rice married Sarah Langdon Abbott on March 20, 1901 and to this union were born Charlotte Rice Rodden and William Abbott Rice.

He was honored with membership in Phi Beta Kappa and Sigma Xi. He was a fellow of AAAS of which he was Vice President and Chairman of Section F in 1903. He held membership in American Society of Naturalists, American Genetics Association, American Association of Anatomists, American Society of Zoologists. He authored a text, "An Introduction to Biology" in 1935, and contributed numerous papers to scientific journals.

Dr. Rice died February 4, 1960. He bequeathed his eyes to the Illinois Society for the Prevention of Blindness, and his body to the School of Medicine of the University of Chicago. His memory will be preserved in Indian Hill Cemetery, Middletown, Connecticut.

Dr. Charles Gallatin Shatzer, a Fellow in the Section of Geography, and President of the Ohio Academy, 1937-38. Dr. Shatzer was born at Shelby, Ohio, December 8, 1877. He received his A.B. degree from Wittenberg College in 1900; his A.M. degree, Wittenberg, 1904; pursued graduate studies for several summers at University of Chicago; awarded honorary degree Sc.D. by Susquehanna University, 1921.

Dr. Shatzer served as principal of the high school, Plain City, Ohio, 1900-01; Instructor in science and mathematics in Wittenberg Academy, 1901-04; organized the Department of Biology and Geology at Wittenberg College in 1904 and taught Geology and Geography. From 1914-1923 and 1925-1946 he was Dean of the College, retiring in 1946 as Dean Emeritus. During the summers of 1911-15 he was on the staff of The Ohio State University Biological Laboratory at Cedar Point.

On June 14, 1917, he married Catherine Greenawalt, who survives him as well as one daughter, Mrs. O. Fred Jaeger, Jr.

In addition to his academic career, he was active in the Lutheran Church, serving as Executive Secretary of the Lutheran Laymen's Movement 1923-25; President, Tecumseh Council, Boy Scouts of America; First President of the Springfield Kiwanis Club, 1919; served in the Ohio Association of Presidents and Deans.

Dr. Shatzer's death on Sept. 12, 1959 was due to acute hemorrhages resulting from gall stones. He was buried in Ferncliff Cemetery, Springfield, Ohio.

Dr. Edgar Nelson Transeau, a Fellow in the Plant Science Section, and President of the Ohio Academy in 1924, Professor Emeritus of Plant Physiology and Ecology, Ohio State University. He was born October 21, 1875 in Williamsport, Pa.

Dr. Transeau received his Bachelor's Degree from Franklin and Marshall College, Lancaster, Pa., 1897 and was the Holder of the Ferry Fellowship at the University of Michigan where he received the Ph.D. degree in 1904. He was Professor of Biology, Alma College, 1904–06; Investigator, Station for Experimental Evolution of the Carnegie Institution, Cold Spring Harbor, Long Island, 1906–07; Professor of Botany, Eastern Illinois Teachers College, Charleston, Ill. 1907–15; Professor of Plant Physiology and Ecology, The Ohio State University, Columbus, Ohio, 1915–46. He retired as Professor Emeritus, 1946.

In 1906 Dr. Transeau married Gertrude Hastings, M.D. of Meadville, Pa. and is survived by one daughter Elizabeth H. (Mrs. August) Mahr of Columbus.

Dr. Transeau was a member of AAAS, 1904–46, Fellow 1908, vice-president for Botany 1941, Active member of Botanical Society of America, 1904–55, president, 1940; Charter member Univ. of Michigan chapter of Sigma Xi, 1904; Member Association of American Geographers, 1905–54; Fellow American Geographical Society 1908–54; Charter member Ecological Society of America, 1915–55, President 1924; American Society of Naturalists 1918–55; National Research Council, Division of Biology and Agriculture, 1928–36; member of the Editorial Board, Ecological Monographs, 1931–34; Honorary member Phi Epsilon Phi, 1935, and Phi Beta Kappa, 1949; Honorary Sc.D. Conferred by Franklin and Marshall College in 1941, and by Ohio State University in 1949; President Phycological Society of America, 1951.

His extensive research resulted in numerous publications and contributions to scientific journals, as well as his test book in General Botany and Laboratory Manual.

He died January 25, 1960 of pulmonary edema.

Dr. William D. Warren, member of the section of Chemistry of the Ohio Academy and Head of the Department of Chemistry, Western College, Oxford, Ohio.

Dr. Warren was born at Akron, N. Y. on July 9, 1896. He attended Elmira Free Academy, 1926; Ph.D. in Chemistry, 1930; all at Cornell University.

He held positions in industry, 1920–25; Western College 1926–29; Head of Department of Chemistry, East Central State College in Ada, Okla. 1930–44; War Production Board in Washington, 1943; Head, Dept. of Chemistry, Western College, 1944 to his death.

On July 19, 1924 he was married to Marjory Hastings, who survives him, as well as a daughter, Dorothy Hastings Warren Rinaldo and a son, William Dwight Warren, Jr.

Dr. Warren was the recipient of several medals and citations in World War I (wounded in action) and held membership in several honorary societies. He was a member of AAAS and the American Chemical Society. He was the author of a Laboratory Manual for College Chemistry.

He died September 29, 1959 of a heart attack and was buried at Oxford, Ohio.

The Scientific Principles of Crop Protection. *Hubert Martin.* Edward Arnold, Ltd. London, England. viii+359 pp. 4th ed., 1959. $12.50. In United States, order from St. Martin's Press, 175 Fifth Avenue, New York City.

Many changes have taken place in plant protection materials since 1940, when the third edition of this book appeared. The major portion of the list of chemicals now used were unknown prior to World War II. These new chemicals have made it possible to control some pests that previously could not be controlled satisfactorily but their use has also created some new problems in the whole control picture.

Subject material covered by chapters is as follows: Introduction, Plant Resistance, Influence of External Factors on the Susceptibility and Liability of Plants to Attack, Biological Control, Fungicides and Insecticides, Measurement and Mechanics of Toxicity, Fungicides, Inorganic Insecticides, Naturally Occurring Contact Insecticides, Synthetic Contact Insecticides, Weedkillers, Fumigants, Seed Treatment, Soil Treatment, Traps, Treatment of the Centers and Vectors of Infection.

A list of references to literature is given at the end of each topic discussed. Both an author index and a subject index complete the book.

Although the new edition covers all phases of crop protection, the principal changes have been on the use of new chemicals. It seems strange to the reviewer that hellebore, sabadilla, and ryania are discussed in the category of miscellaneous stomach poisons in the chapter on inorganic compounds, rather than in the chapter on naturally occurring contact insecticides, along with nicotine, rotenone, and pyrethrum. No mention is made that the source of most rotenone insecticides is primarily the roots of derris and cube plants. Dugvelin is spelled incorrectly at the bottom of p. 176. The overall presentation appears to be good and the author is to be commended for his efforts in completing this new edition. It should serve a useful purpose in the library of every entomologist interested in control of insects.

R. H. Davidson

NOTICE TO OHIO NATURALISTS

NATURAL AREAS PROJECT

The Ohio Biological Survey, an organization of more than 25 Ohio institutions, has been anxious to sponsor an inventory of natural areas within the state. Such an inventory will have much value to specialists in many fields, to teachers, to naturalists, and to those groups especially interested in the preservation of such areas. With the cooperation of many persons throughout Ohio, this project got under way in the spring of 1959 and progress to date has been most encouraging.

Objectives.—Truly virgin areas within Ohio are almost nonexistent. Even so, we desire to collect data on all areas which are still sufficiently natural and distinctive enough to be of interest to biologists, naturalists, teachers and conservationists. To be worthy of reporting, an area needs to be unique only to the extent that it is one of the best habitats of its type in its vicinity. (The area may be the only remnant of a once common habitat, such as a glacial bog in the midst of a muck farm community.) Data on significant species, types of habitat, location and present ownership will be assembled, and pertinent information concerning the need for protecting the area by purchase, regulation, or other means will be included. Such data will be made available to all qualified persons. We are already working closely with the Ohio Chapter of Nature Conservancy in efforts to preserve our most valuable natural areas.

Methods.—This project must be a cooperative effort. By means of letters, personal contacts, academy meetings, and publications, we wish to encourage all qualified persons to contribute data. Forms for reporting areas are sent to all who show an interest. Once we recieve a preliminary report, we will pursue it further by letter writing, reading, conferences, and actual visits to areas.

Results to date.—Thanks to the efforts of some of Ohio's leading professional biologists, as well as to many able amateurs, we now have preliminary reports on about 130 areas, sent in by no less than 50 contributors and representing more than half of our 88 counties. Among the areas listed are bogs, swamps, ponds, sand dunes, heronries, prairies, virgin and non-virgin forests, etc. We are well started, but only started.

Help wanted.—This project still needs much help. If you are familiar with any interesting *natural* area anyplace in Ohio, please inform us of it. Your card or letter will promptly bring you a more detailed account of what is needed, a list of the natural areas already on record, and a form for reporting data. Address all information to the Natural Areas Project Leader, J. Arthur Herrick, Kent State University.

TAXONOMY AND DISTRIBUTION OF ODONATA IN OHIO

The Ohio Biological Survey has also accepted sponsorship of a project leading to the publication of a Bulletin on the Odonata (Dragonflies and Damselflies) of Ohio, with Robert W. Alrutz, Denison University, as its leader

Initial research began this summer and consists of a faunistic study of the geographic and seasonal distribution of the Ohio species. Efforts are being made to: (a) examine all available collections whose data have not been published, including private as well as institutional collections; (b) solicit the cooperation of those who may collect specimens for contribution to the project or whose data may be used; and (c) do field collecting in those parts of Ohio which have thus far been little collected.

To this end, information is solicited as to the location of natural waters such as swamps, bogs, natural pools, and relatively undisturbed streams. These data, together with pertinent life-history and taxonomic information, will then ultimately be incorporated into the proposed Bulletin. The impending problem is the solicitation of assistance from others. For this reason, we are seeking information concerning the location of collectors or persons who would be willing to collect for us.

Please contact the project leader.

The Garden Flowers of China. *H. L. Li.* Ronald Press. 1959. xxv+240 pp. $6.50.

To introduce a subject like The Garden Flowers of China to the western world, few are better qualified than this China-born and Harvard-educated taxonomist, Dr. H. L. Li. Li is probably the first Chinese to be credited for completing such an effort in great detail, although E. H. Wilson (1929) long ago pointed out that "China is indeed the mother of gardens; the country to which the gardens of all other lands are so deeply indebted."

Li's treatment is unique and interesting. He has covered a diversified variety of species, such as the gorgeous peony, the 'virtuous' apricot, legendary peach blossom, poetic chrysanthemum, sacred lotus, distinguished orchid, graceful camellia, festival lily, exquisite rose, mysterious Jade flower, as well as many other flowering herbs, shrubs, and trees. One is led to appreciate that most of these well-known garden plants of the Western world have their origin in China. Li has taken advantage of the richness of ancient Chinese art. Many of the species in the book are illustrated by reproductions of artistically beautiful and scientifically precise ancient paintings (as far back as 850 years). This not only compensates his lack of photographs from fresh material but adds a novel and exotic flavor as well. Li is successful in tying folklore, legend, literature, and authentic recorded history into his presentation. The unity of classical Chinese art and science, especially in the field of botanical subjects, is impressive and stimulating. Special merit should be given to the lengthy bibliography, in Chinese with English translation, of ancient Chinese horticultural publications. The list is certainly of great value to many concerned.

There are, nevertheless, pitfalls in the book. The index to Chinese names (pages 229–231), for example, is most disappointing. Since there are other systems besides Wade's of latinizing Chinese characters and there are often several names applied to the same plant in Chinese, simply latinizing a few Chinese plant names is of little significance. It would necessarily take a Chinese student in Botany to recognize, for instance, that both Tu Chüan and Yang Chih Chu refer to *Azalea* and that Yülan, Mulan, Hsin I and Mu Pi are all *Magnolia*. Li could have improved his book by compiling a table, listing for each plant the common synonyms in Chinese, and in English if any, their latinized names, and the scientific names. Also, his horticultural center map (fig. 1) would be more meaningful if the distribution of various species had been shown on it.

The art and science of a nation are often intermingled from many angles. A thorough understanding and appreciation of the culture and civilization of a nation can be obtained only with the aid of genuine interpretation, not mere translation. Above all, Li should be congratulated for his contribution in materializing one aspect of Goethe's idea of the belongingness of art and science to the whole world. In general, botanists—orthodox or experimental, horticulturists—gardening or ornamental, artists—descriptive or abstractive, as well as historians—natural or orientalistic would find this book enjoyable reading and worth owning.

P. C. Huang

Adventures with the Missing Link. *Raymond A. Dart* and *Dennis Craig.* Harper & Brothers, New York. 1959. xxi+255 pp. $5.00.

Since the initial report on the controversial "Dart's Child" appeared in 1925, this book has been long anticipated. With commendable thoroughness, Professor Dart and his coworkers have collected and analyzed the primate remains from Taungs—Sterkfontein—Makapansgat excavations in South Africa. To the Australopithicines of this area Dart assigns an "osteodontokeratic" (bone-tooth-horn) culture as an earlier stage in human evolution than that previously described for paleolithic cultures. If, as has been suggested, the key which admits to classification as ***human*** is, "The Making of Tools after a Definite Pattern," Dr. Dart has here presented ample evidence for the recognition of Australopithecus as definite human type. The professional anthropologist has been aware of this type for some years but to the laymen, this volume brings a revealing message in the ever-fascinating search for human origins.

R. A. Hefner

Bees—their Vision, Chemical Senses, and Language. *Karl von Frisch.* Cornell University Press, Ithaca, N. Y. 1956. 115 pp. $1.45. Foreward by Donald R. Griffin. Great Seal Books of Cornell Press. Paperbound.

This is a reprint of the 1950 hard cover edition. As soon as it was published, this work of von Frisch became a modern classic. In this edition it can be obtained for about a third of the original cost. It is not only a source of data on controlled experimentation, it is a pleasure to read as a model of sprightly simple exposition. A lifetime of complicated effort is presented in a disarmingly easy manner by this distinguished zoologist. As the foreword states, "appreciation of a scientist's mode of thinking requires more than a bare scratching of phenomena, hypotheses, experiments, and conclusion." The thinking that resulted in Chapter Three is likely to affect your attitude toward experiment and observation.

A. E. Waller